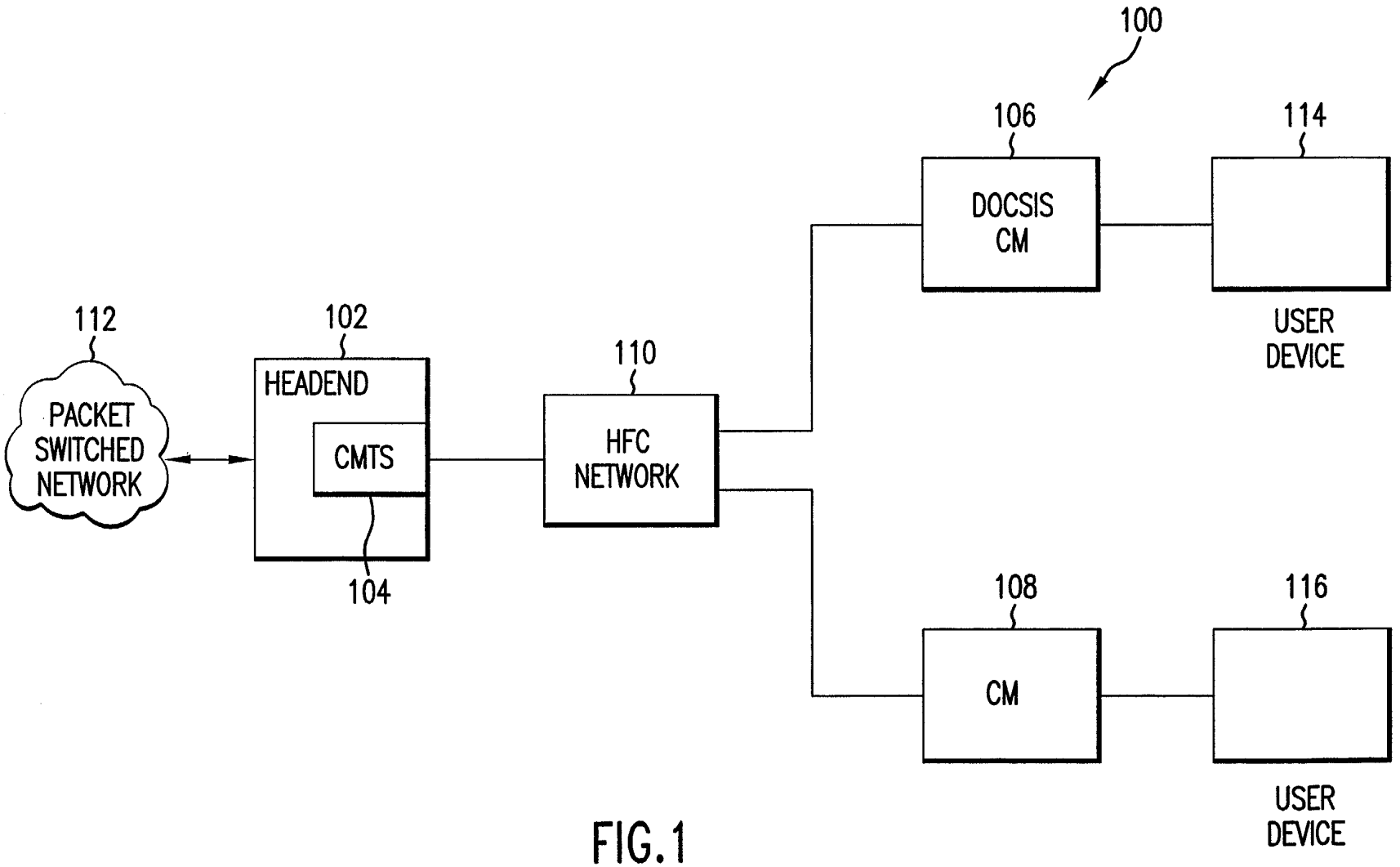
100
106
114
DOCSIS CM
USER DEVICE
112
102
110
PACKET SWITCHED NETWORK
HEADEND
CMTS
HFC NETWORK
104
108
116
CM
USER DEVICE

FIG.1

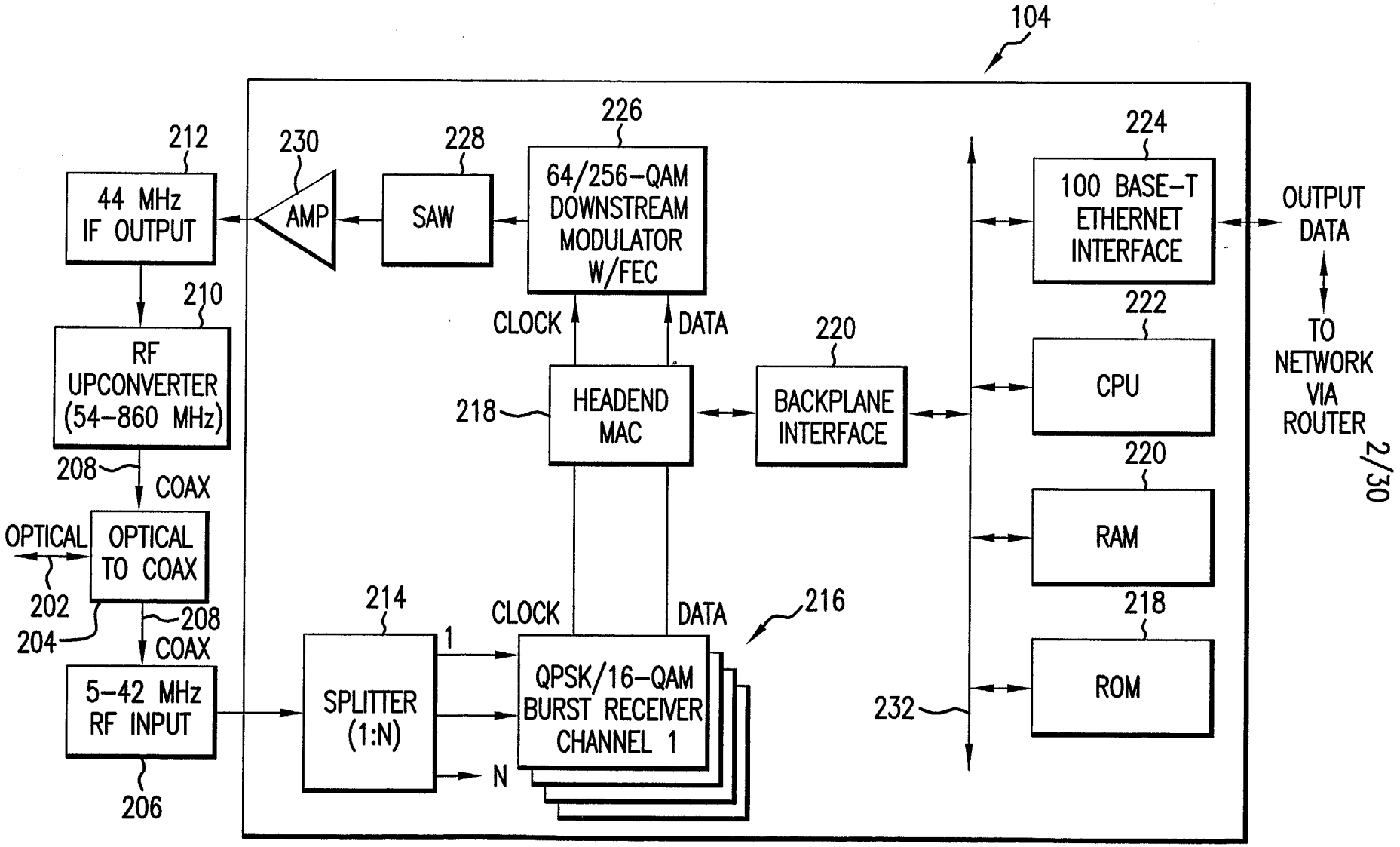
104
212
44 MHz IF OUTPUT
230
AMP
228
SAW
226
64/256-QAM DOWNSTREAM MODULATOR W/FEC
224
100 BASE-T ETHERNET INTERFACE
OUTPUT DATA
TO NETWORK VIA ROUTER
210
RF UPCONVERTER (54-860 MHz)
CLOCK
DATA
220
222
CPU
218
HEADEND MAC
BACKPLANE INTERFACE
208
COAX
220
RAM
OPTICAL
OPTICAL TO COAX
202
204
208
COAX
214
CLOCK
DATA
216
218
ROM
1
5-42 MHz RF INPUT
SPLITTER (1:N)
QPSK/16-QAM BURST RECEIVER CHANNEL 1
N
232
206

FIG.2

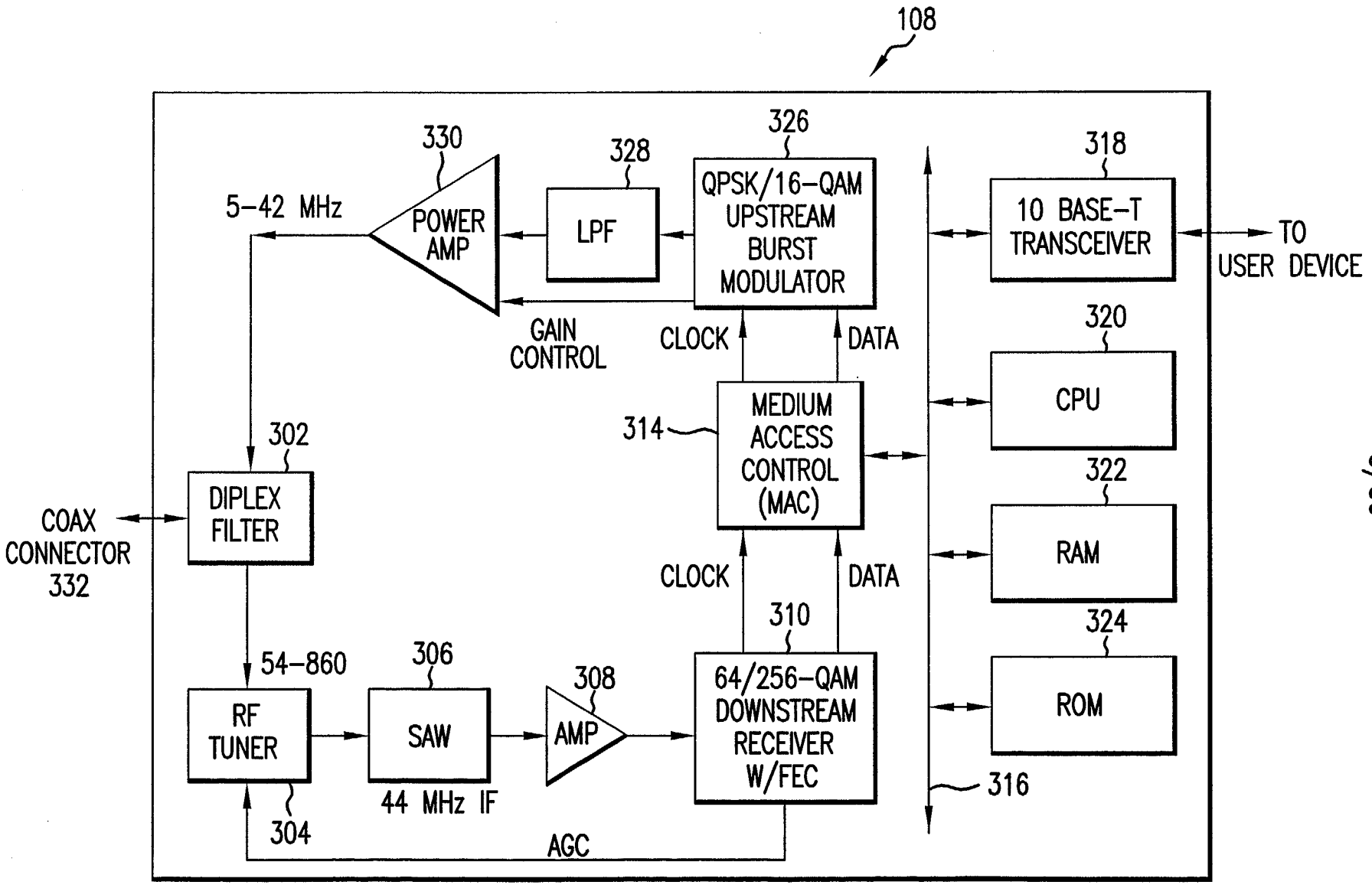
108
330
POWER AMP
5–42 MHz
328
LPF
326
QPSK/16–QAM UPSTREAM BURST MODULATOR
318
10 BASE–T TRANSCEIVER
TO USER DEVICE
GAIN CONTROL
CLOCK
DATA
320
CPU
314
MEDIUM ACCESS CONTROL (MAC)
322
RAM
302
DIPLEX FILTER
COAX CONNECTOR 332
CLOCK
DATA
310
324
ROM
54–860
306
308
RF TUNER
SAW
AMP
64/256–QAM DOWNSTREAM RECEIVER W/FEC
316
44 MHz IF
304
AGC

FIG.3

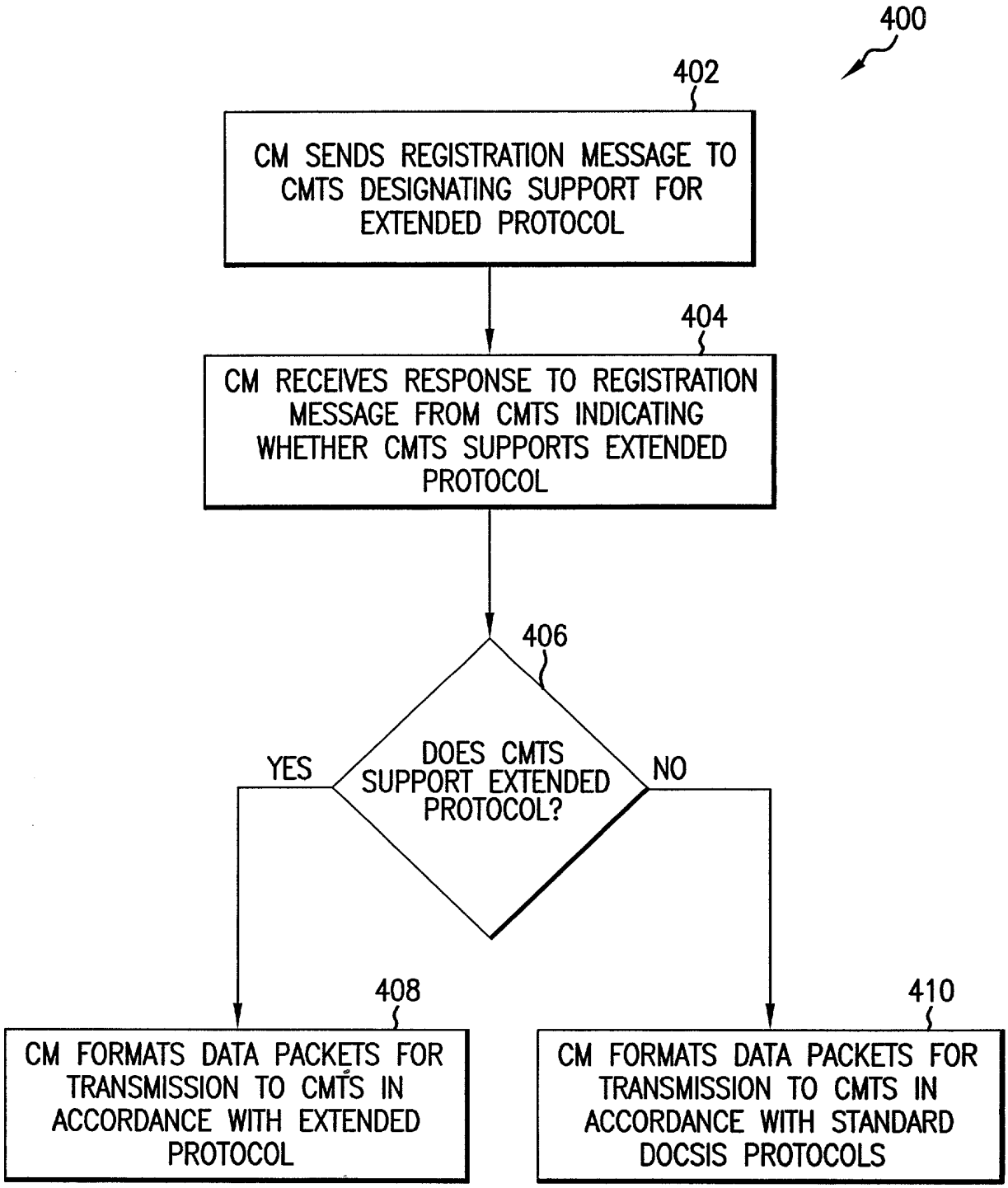
400
402
CM SENDS REGISTRATION MESSAGE TO CMTS DESIGNATING SUPPORT FOR EXTENDED PROTOCOL
404
CM RECEIVES RESPONSE TO REGISTRATION MESSAGE FROM CMTS INDICATING WHETHER CMTS SUPPORTS EXTENDED PROTOCOL
406
DOES CMTS SUPPORT EXTENDED PROTOCOL?
YES
NO
408
CM FORMATS DATA PACKETS FOR TRANSMISSION TO CMTS IN ACCORDANCE WITH EXTENDED PROTOCOL
410
CM FORMATS DATA PACKETS FOR TRANSMISSION TO CMTS IN ACCORDANCE WITH STANDARD DOCSIS PROTOCOLS

FIG.4

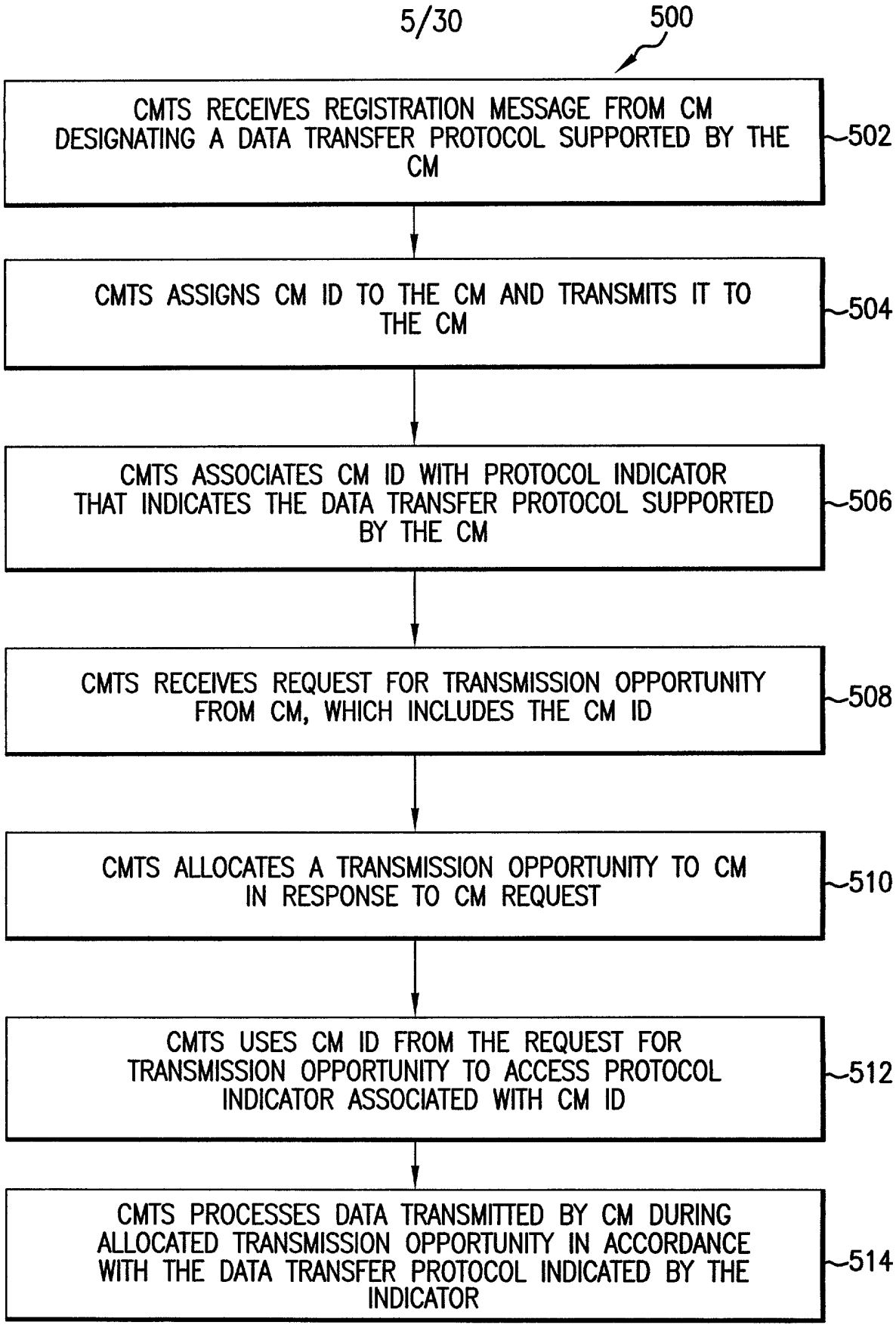
500
CMTS RECEIVES REGISTRATION MESSAGE FROM CM DESIGNATING A DATA TRANSFER PROTOCOL SUPPORTED BY THE CM
502
CMTS ASSIGNS CM ID TO THE CM AND TRANSMITS IT TO THE CM
504
CMTS ASSOCIATES CM ID WITH PROTOCOL INDICATOR THAT INDICATES THE DATA TRANSFER PROTOCOL SUPPORTED BY THE CM
506
CMTS RECEIVES REQUEST FOR TRANSMISSION OPPORTUNITY FROM CM, WHICH INCLUDES THE CM ID
508
CMTS ALLOCATES A TRANSMISSION OPPORTUNITY TO CM IN RESPONSE TO CM REQUEST
510
CMTS USES CM ID FROM THE REQUEST FOR TRANSMISSION OPPORTUNITY TO ACCESS PROTOCOL INDICATOR ASSOCIATED WITH CM ID
512
CMTS PROCESSES DATA TRANSMITTED BY CM DURING ALLOCATED TRANSMISSION OPPORTUNITY IN ACCORDANCE WITH THE DATA TRANSFER PROTOCOL INDICATED BY THE INDICATOR
514

FIG.5

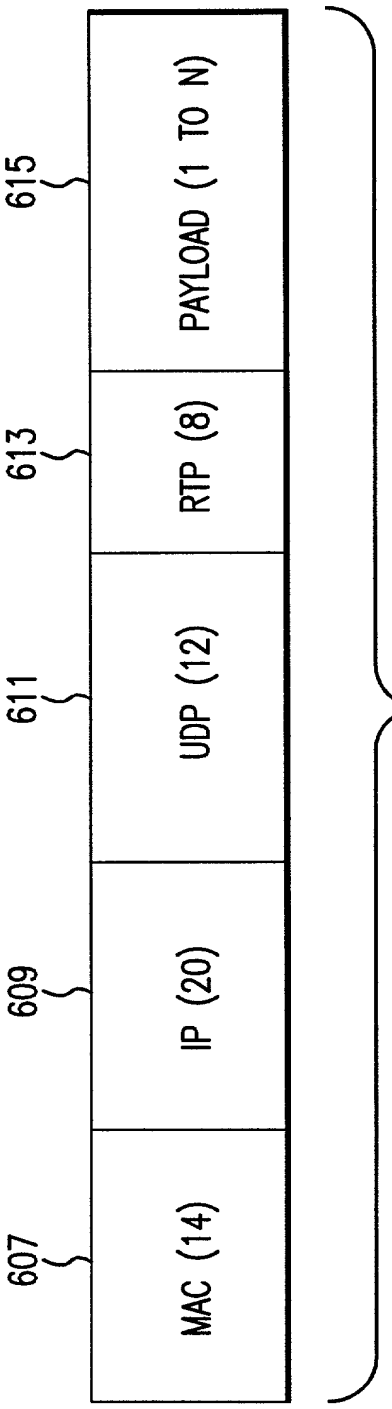

FIG.6A

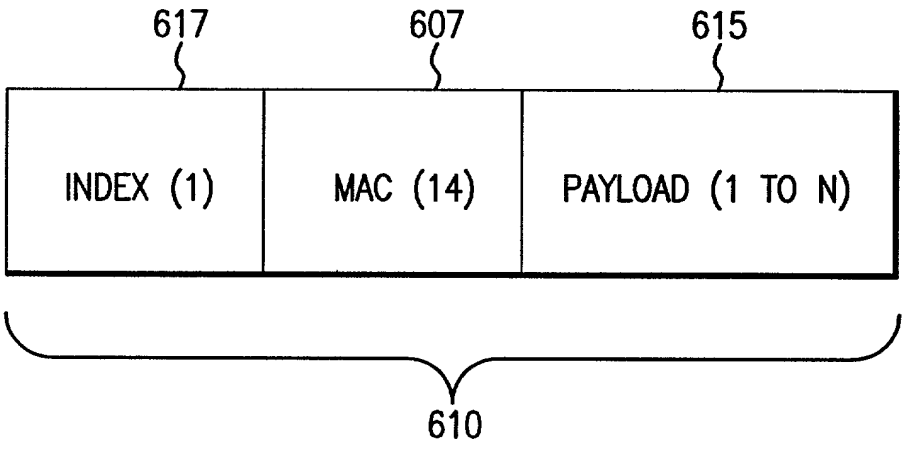

FIG.6B

20070-1282660

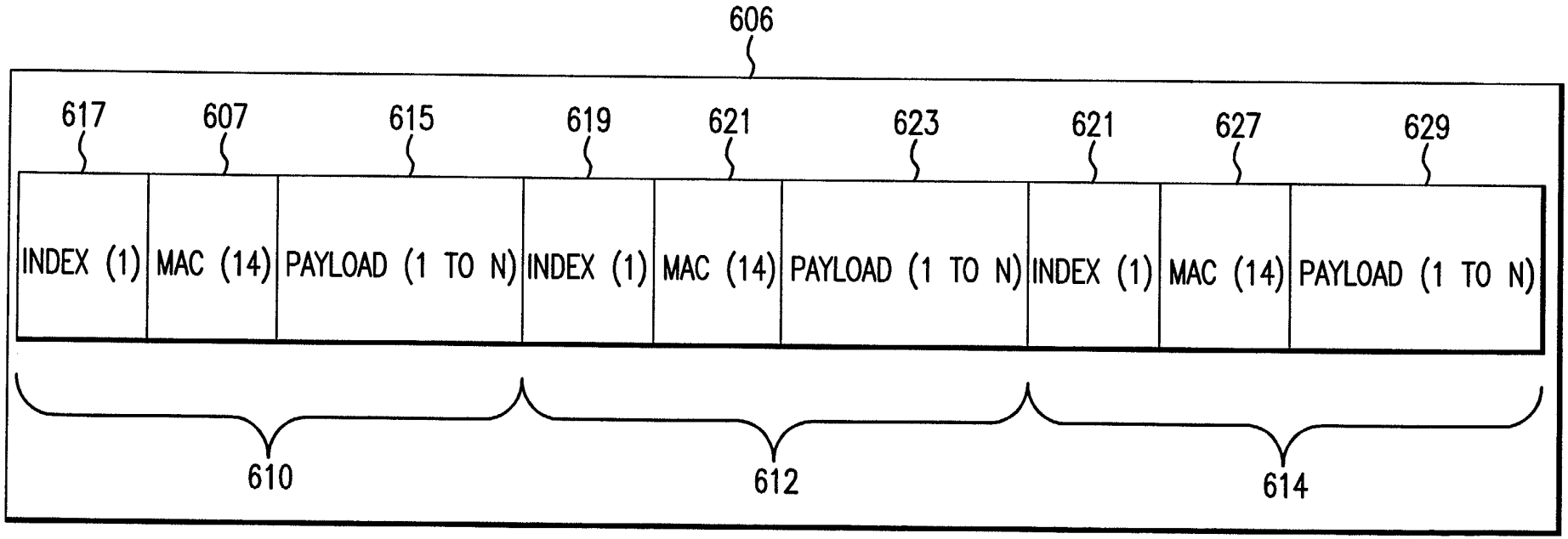

FIG.6C

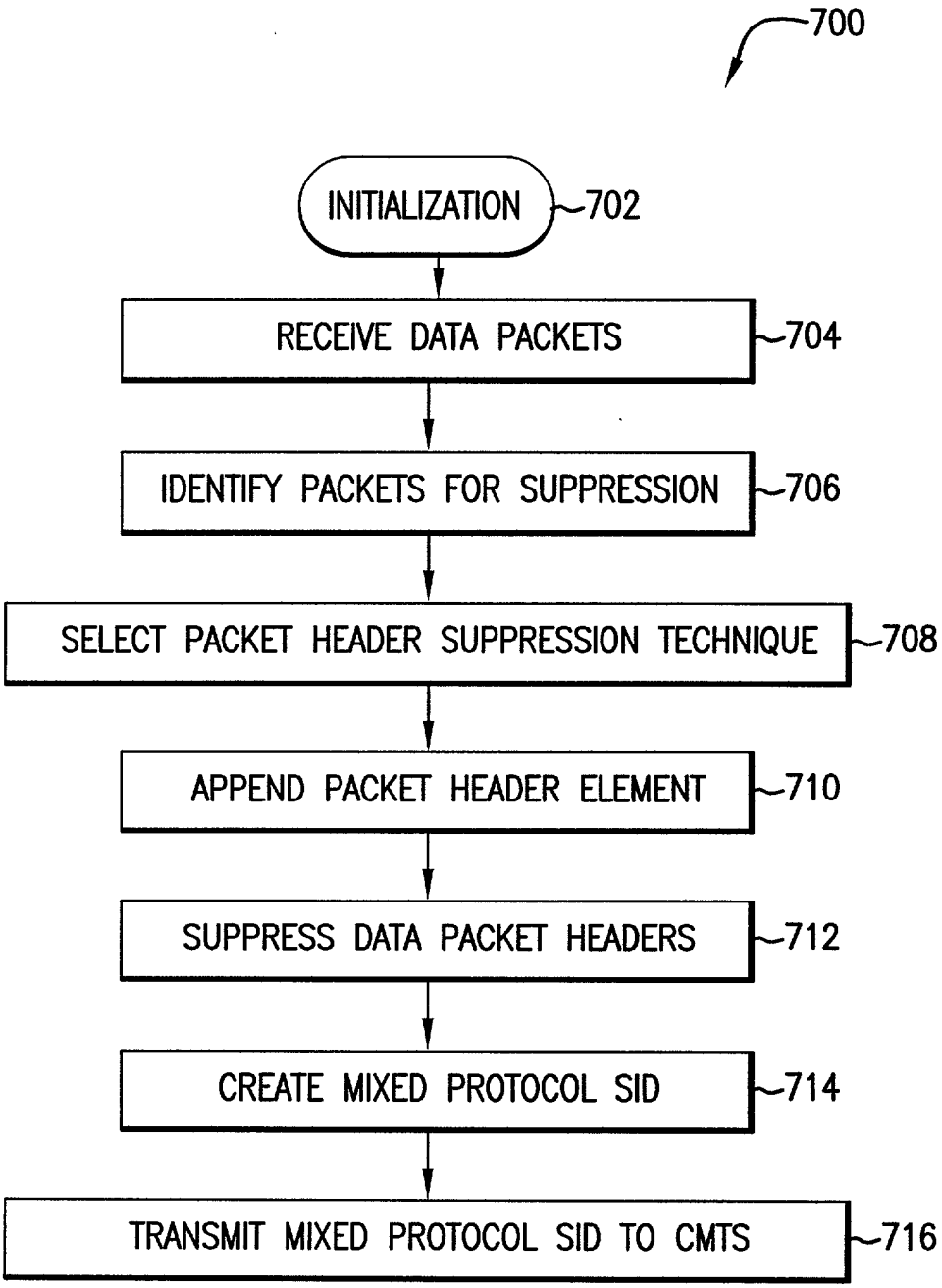
700
INITIALIZATION
702
RECEIVE DATA PACKETS
704
IDENTIFY PACKETS FOR SUPPRESSION
706
SELECT PACKET HEADER SUPPRESSION TECHNIQUE
708
APPEND PACKET HEADER ELEMENT
710
SUPPRESS DATA PACKET HEADERS
712
CREATE MIXED PROTOCOL SID
714
TRANSMIT MIXED PROTOCOL SID TO CMTS
716

FIG.7

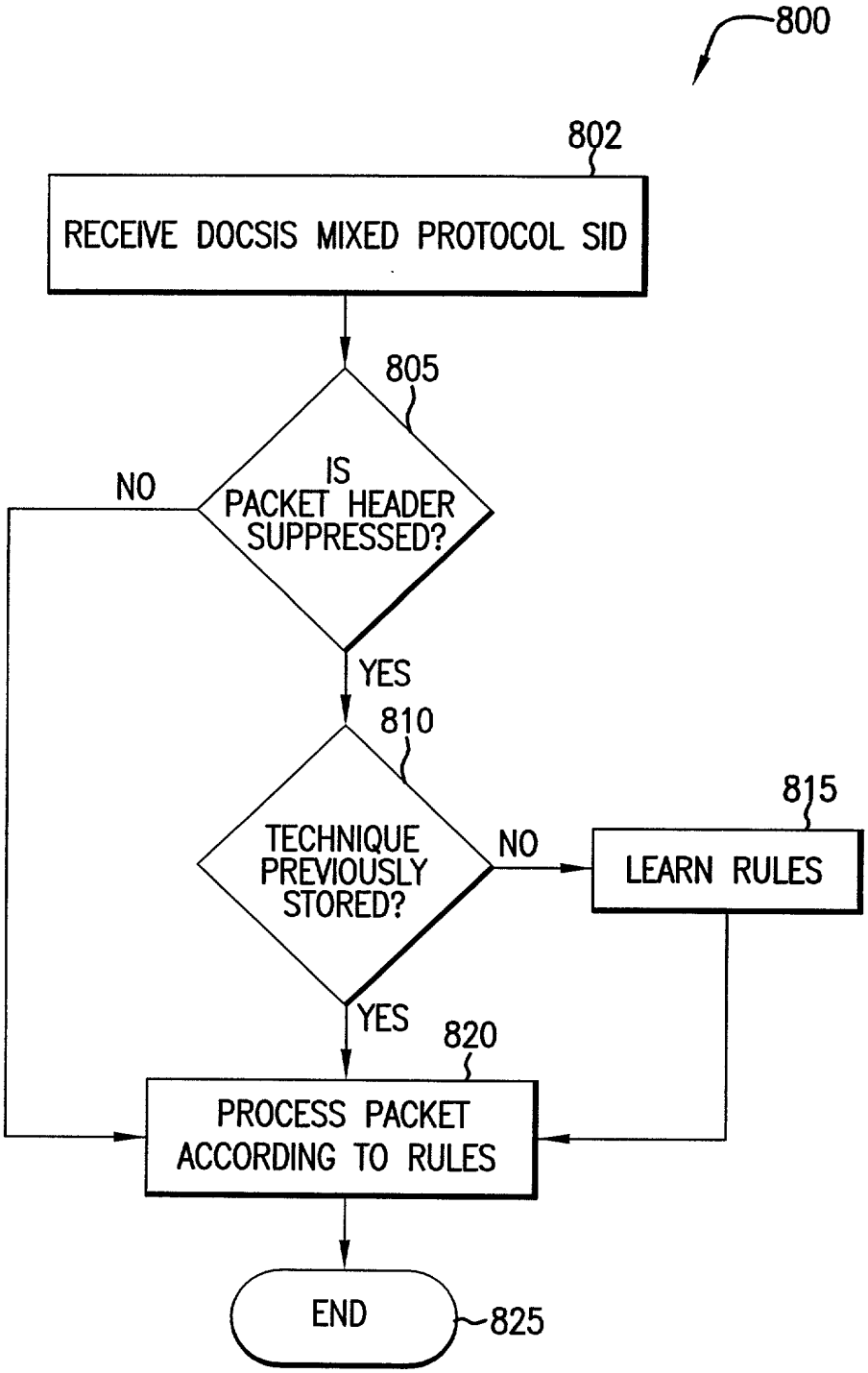
800
802
RECEIVE DOCSIS MIXED PROTOCOL SID
805
IS PACKET HEADER SUPPRESSED?
NO
YES
810
TECHNIQUE PREVIOUSLY STORED?
NO
815
LEARN RULES
YES
820
PROCESS PACKET ACCORDING TO RULES
END
825

FIG.8

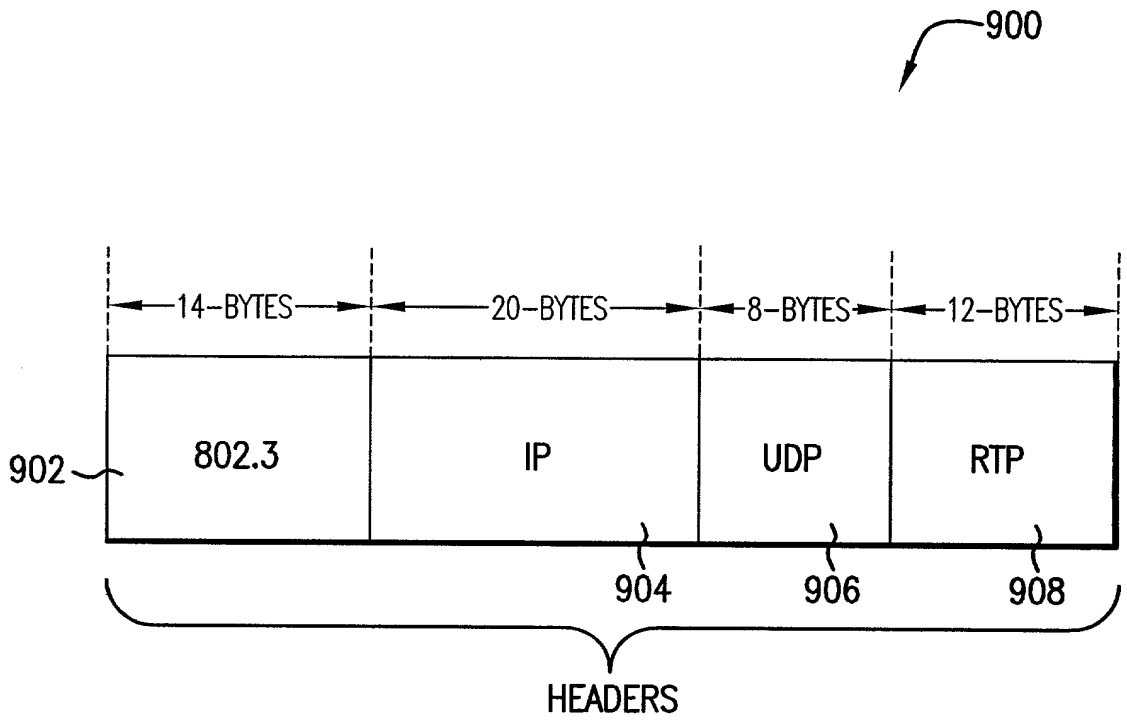
900
14-BYTES
20-BYTES
8-BYTES
12-BYTES
902
802.3
IP
UDP
RTP
904
906
908
HEADERS

FIG.9A

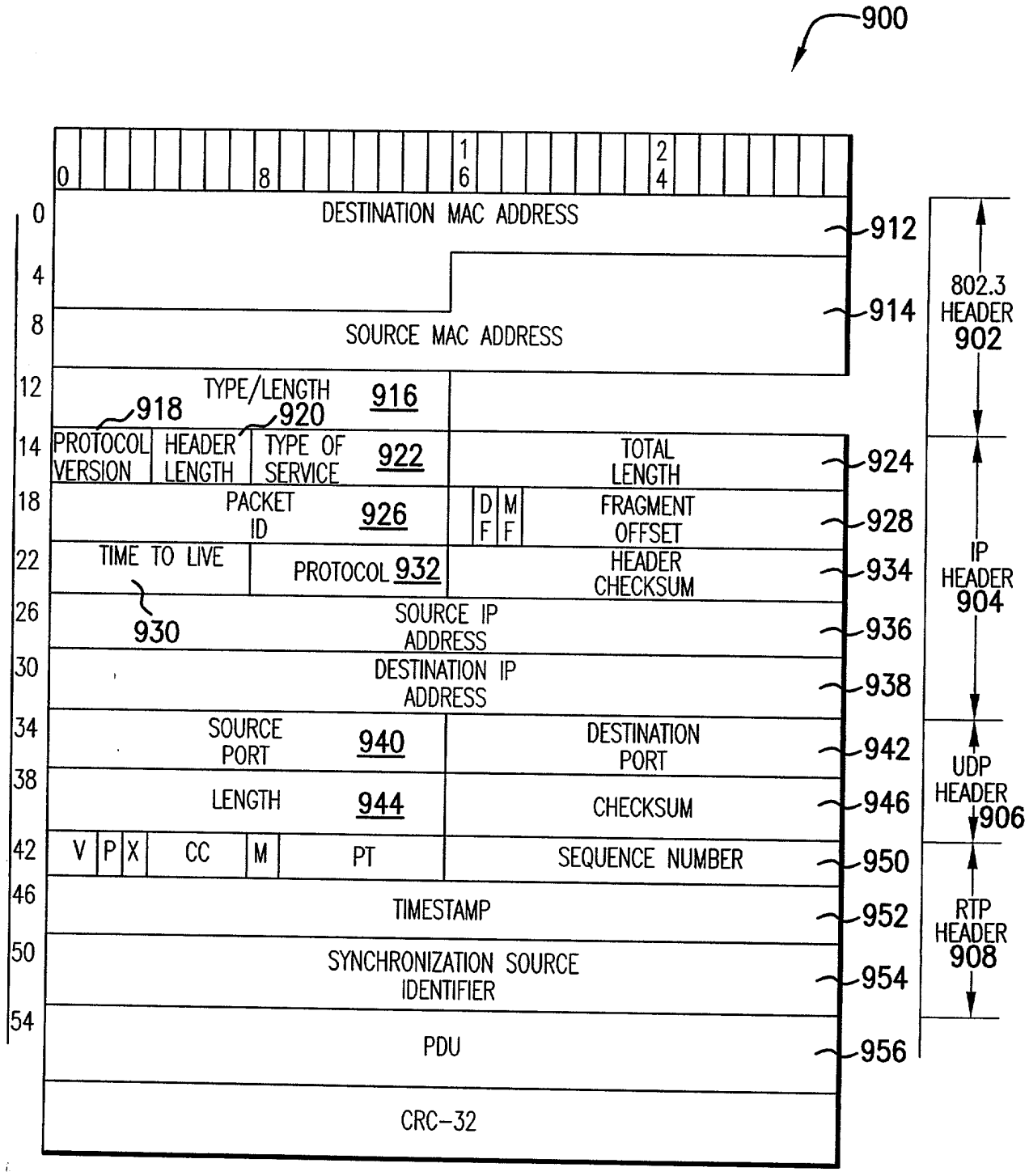
900
0
8
16
24
0
DESTINATION MAC ADDRESS
912
4
8
SOURCE MAC ADDRESS
914
802.3 HEADER 902
12
TYPE/LENGTH 916
14
PROTOCOL VERSION
HEADER LENGTH
TYPE OF SERVICE 922
TOTAL LENGTH
924
18
PACKET ID 926
DF
MF
FRAGMENT OFFSET
928
22
TIME TO LIVE
PROTOCOL 932
HEADER CHECKSUM
934
IP HEADER 904
26
930
SOURCE IP ADDRESS
936
30
DESTINATION IP ADDRESS
938
34
SOURCE PORT 940
DESTINATION PORT
942
38
LENGTH 944
CHECKSUM
946
UDP HEADER 906
42
V
P
X
CC
M
PT
SEQUENCE NUMBER
950
46
TIMESTAMP
952
RTP HEADER 908
50
SYNCHRONIZATION SOURCE IDENTIFIER
954
54
PDU
956
CRC-32

FIG.9B

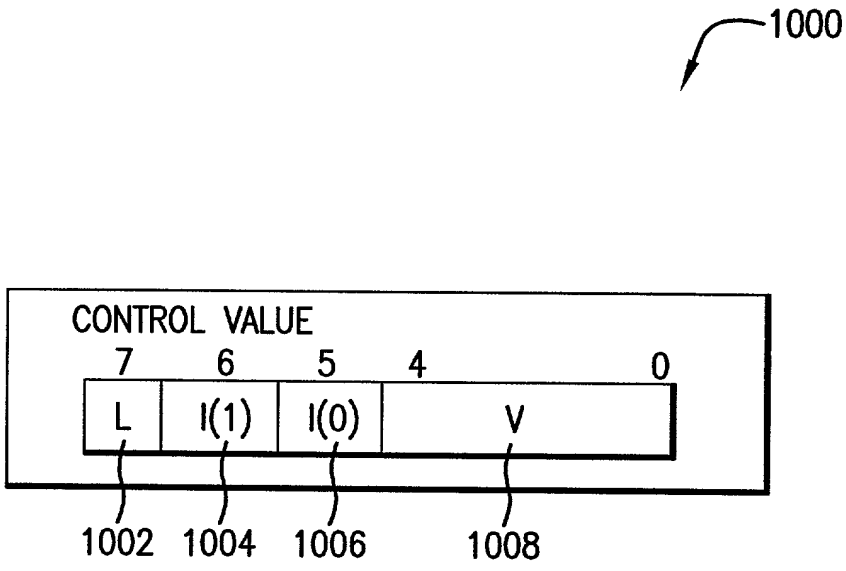

FIG.10

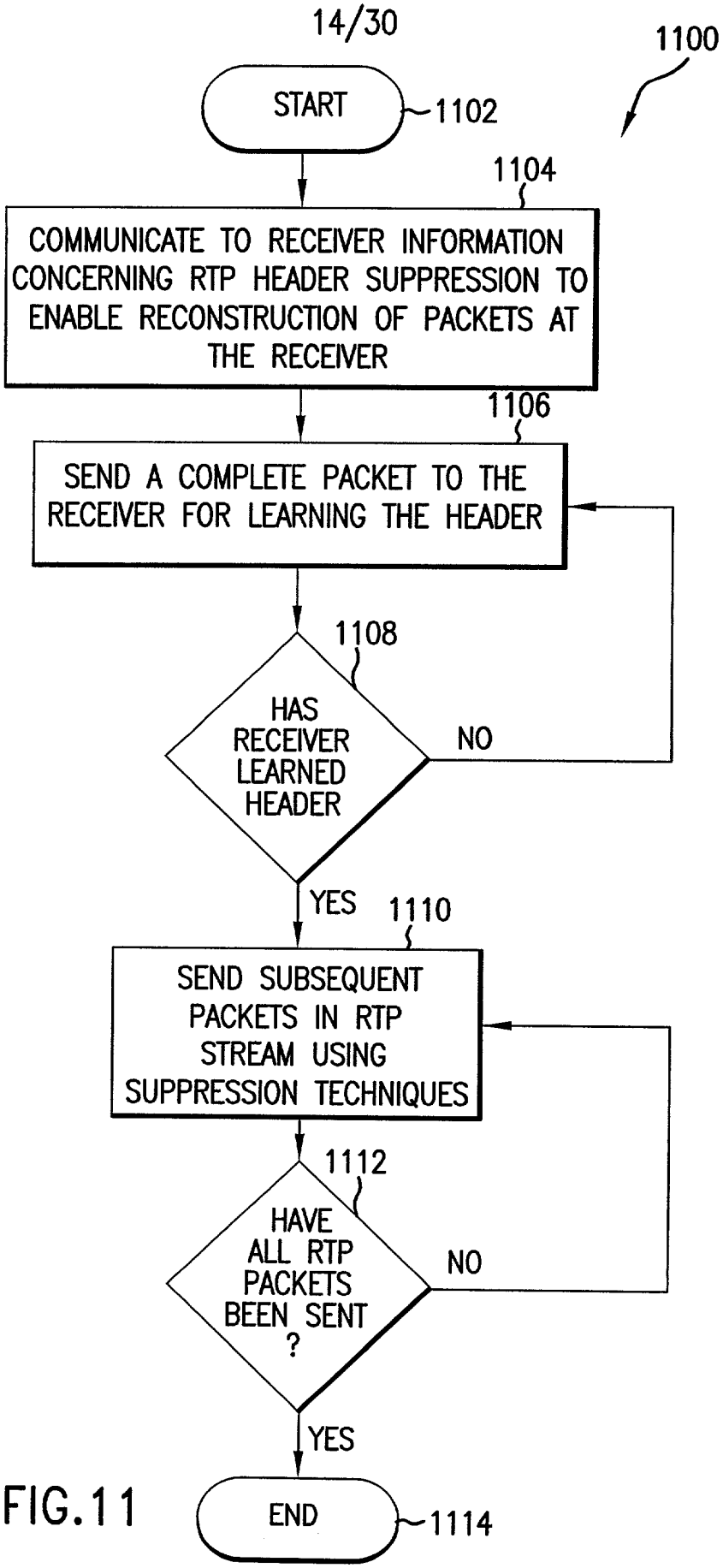
1100
START
1102
1104
COMMUNICATE TO RECEIVER INFORMATION CONCERNING RTP HEADER SUPPRESSION TO ENABLE RECONSTRUCTION OF PACKETS AT THE RECEIVER
1106
SEND A COMPLETE PACKET TO THE RECEIVER FOR LEARNING THE HEADER
1108
HAS RECEIVER LEARNED HEADER
NO
YES
1110
SEND SUBSEQUENT PACKETS IN RTP STREAM USING SUPPRESSION TECHNIQUES
1112
HAVE ALL RTP PACKETS BEEN SENT ?
NO
YES
END
1114

FIG.11

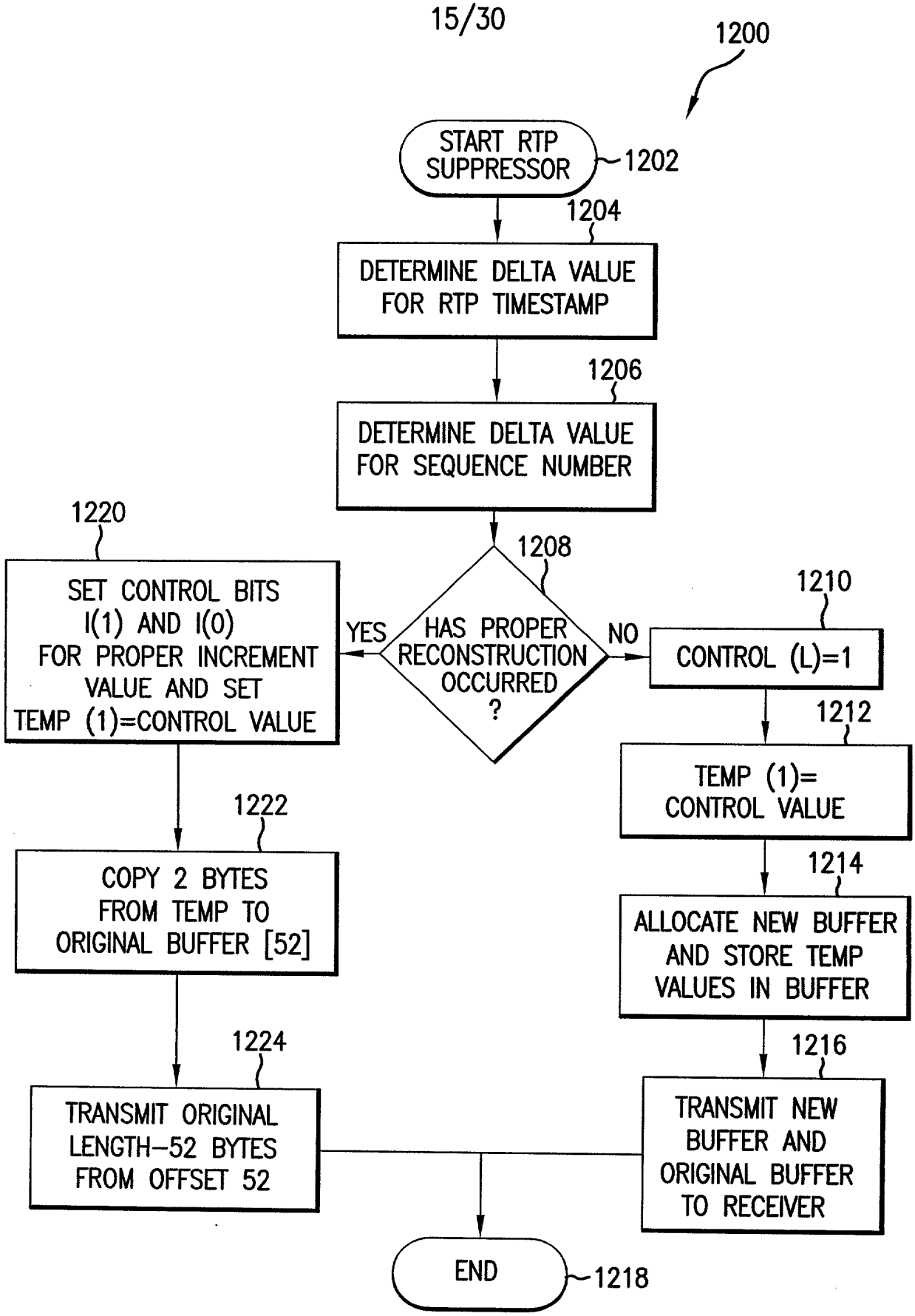
1200
START RTP SUPPRESSOR
1202
1204
DETERMINE DELTA VALUE FOR RTP TIMESTAMP
1206
DETERMINE DELTA VALUE FOR SEQUENCE NUMBER
1208
HAS PROPER RECONSTRUCTION OCCURRED ?
YES
NO
1220
SET CONTROL BITS I(1) AND I(0) FOR PROPER INCREMENT VALUE AND SET TEMP (1)=CONTROL VALUE
1210
CONTROL (L)=1
1212
TEMP (1)= CONTROL VALUE
1214
ALLOCATE NEW BUFFER AND STORE TEMP VALUES IN BUFFER
1216
TRANSMIT NEW BUFFER AND ORIGINAL BUFFER TO RECEIVER
1222
COPY 2 BYTES FROM TEMP TO ORIGINAL BUFFER [52]
1224
TRANSMIT ORIGINAL LENGTH-52 BYTES FROM OFFSET 52
END
1218

FIG.12A

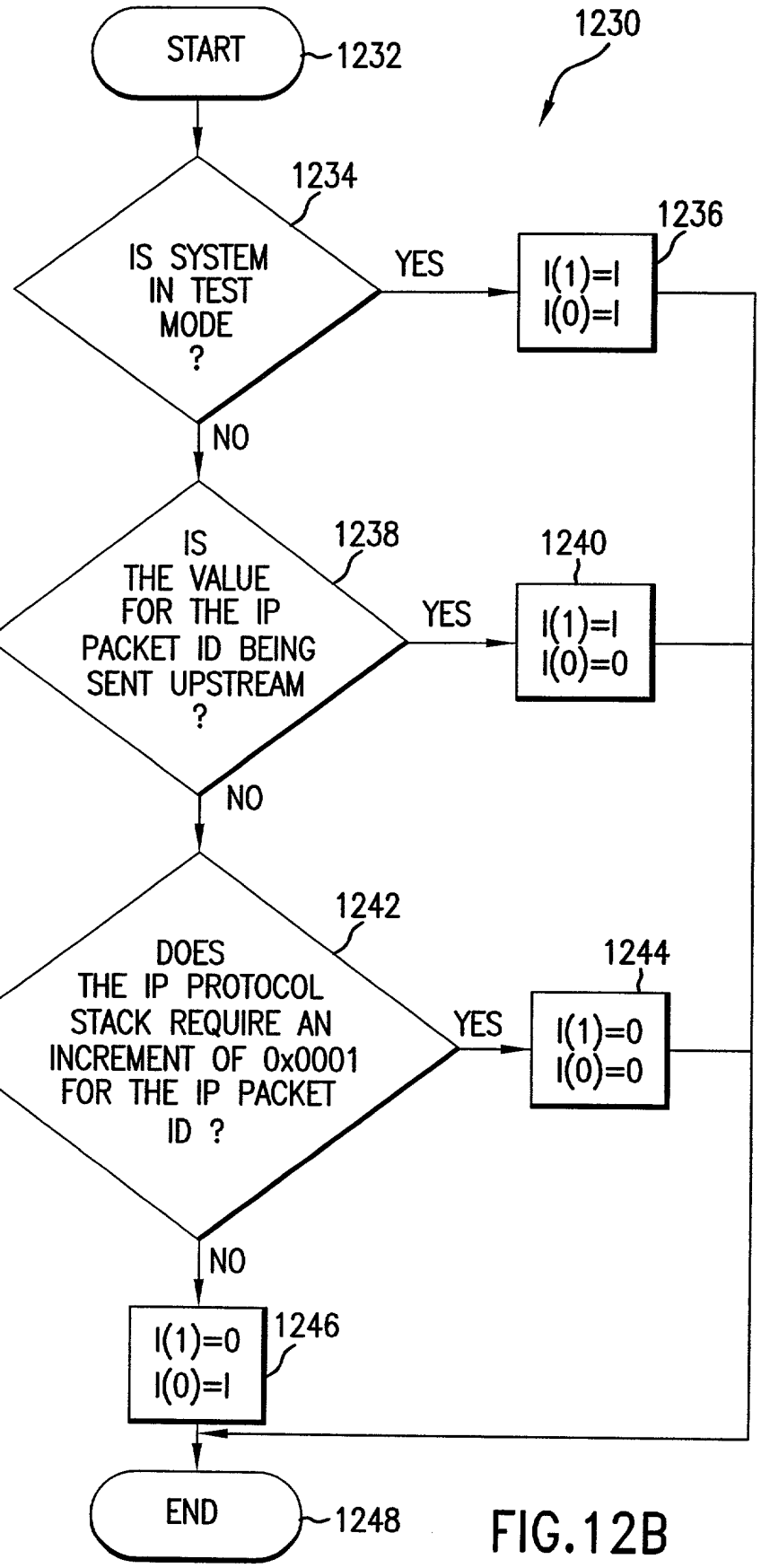
START
1232
1230
1234
IS SYSTEM IN TEST MODE ?
YES
1236
I(1)=I
I(0)=I
NO
IS THE VALUE FOR THE IP PACKET ID BEING SENT UPSTREAM ?
1238
YES
1240
I(1)=I
I(0)=0
NO
DOES THE IP PROTOCOL STACK REQUIRE AN INCREMENT OF 0x0001 FOR THE IP PACKET ID ?
1242
YES
1244
I(1)=0
I(0)=0
NO
I(1)=0
I(0)=I
1246
END
1248

FIG.12B

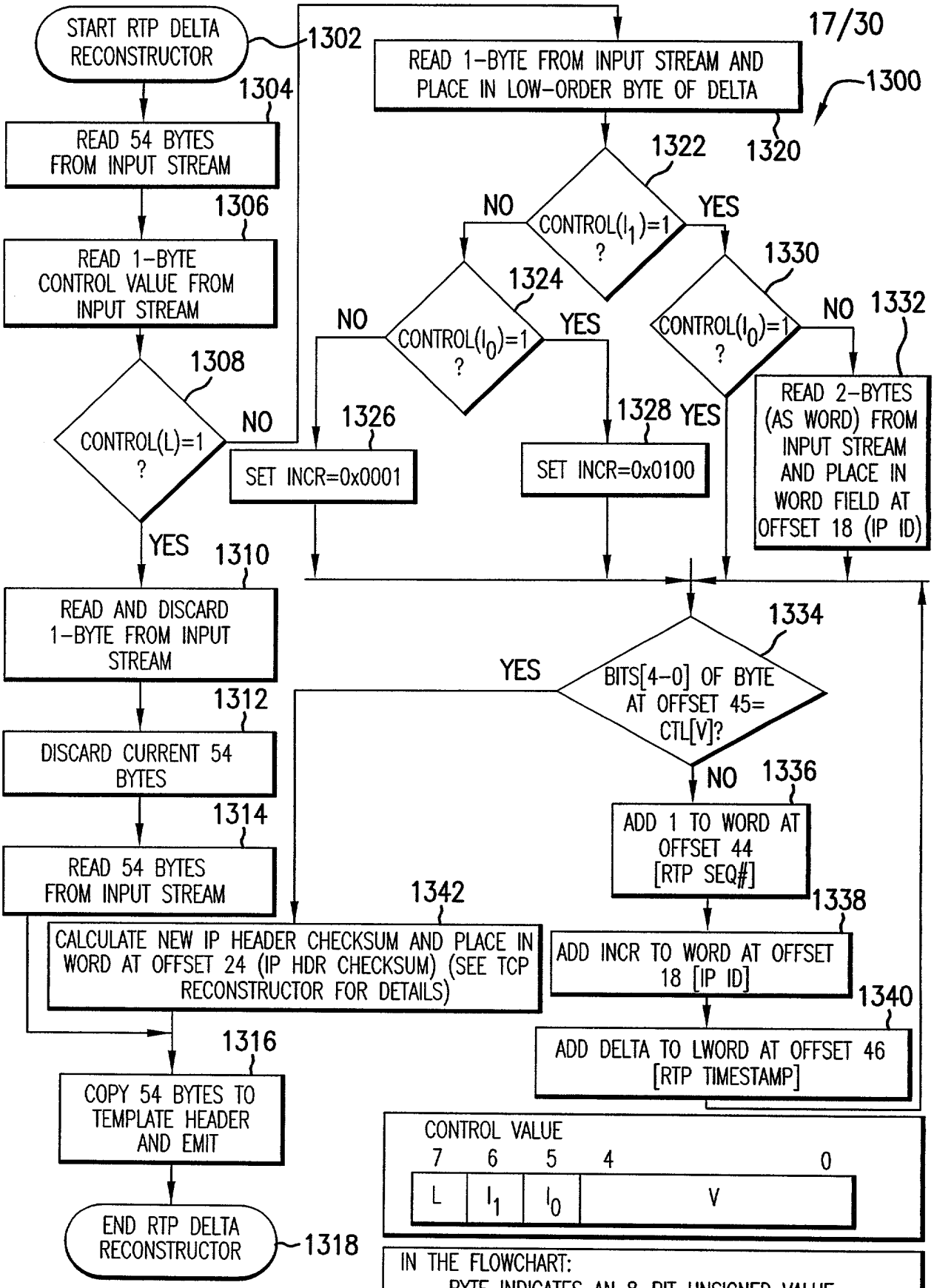
START RTP DELTA RECONSTRUCTOR
1302
READ 1-BYTE FROM INPUT STREAM AND PLACE IN LOW-ORDER BYTE OF DELTA
1300
1320
1304
READ 54 BYTES FROM INPUT STREAM
1306
READ 1-BYTE CONTROL VALUE FROM INPUT STREAM
1308
CONTROL(L)=1 ?
NO
YES
1310
READ AND DISCARD 1-BYTE FROM INPUT STREAM
1312
DISCARD CURRENT 54 BYTES
1314
READ 54 BYTES FROM INPUT STREAM
1316
COPY 54 BYTES TO TEMPLATE HEADER AND EMIT
END RTP DELTA RECONSTRUCTOR
1318
1322
CONTROL(I_1)=1 ?
NO
YES
1324
CONTROL(I_0)=1 ?
NO
YES
1326
SET INCR=0x0001
1328
SET INCR=0x0100
1330
CONTROL(I_0)=1 ?
NO
YES
1332
READ 2-BYTES (AS WORD) FROM INPUT STREAM AND PLACE IN WORD FIELD AT OFFSET 18 (IP ID)
1334
BITS[4-0] OF BYTE AT OFFSET 45= CTL[V]?
YES
NO
1336
ADD 1 TO WORD AT OFFSET 44 [RTP SEQ#]
1338
ADD INCR TO WORD AT OFFSET 18 [IP ID]
1340
ADD DELTA TO LWORD AT OFFSET 46 [RTP TIMESTAMP]
1342
CALCULATE NEW IP HEADER CHECKSUM AND PLACE IN WORD AT OFFSET 24 (IP HDR CHECKSUM) (SEE TCP RECONSTRUCTOR FOR DETAILS)
CONTROL VALUE
7 6 5 4 0
L I_1 I_0 V
IN THE FLOWCHART:
BYTE INDICATES AN 8-BIT UNSIGNED VALUE
WORD INDICATES A 16-BIT UNSIGNED VALUE
LWORD INDICATES A 32-BIT UNSIGNED VALUE

FIG.13

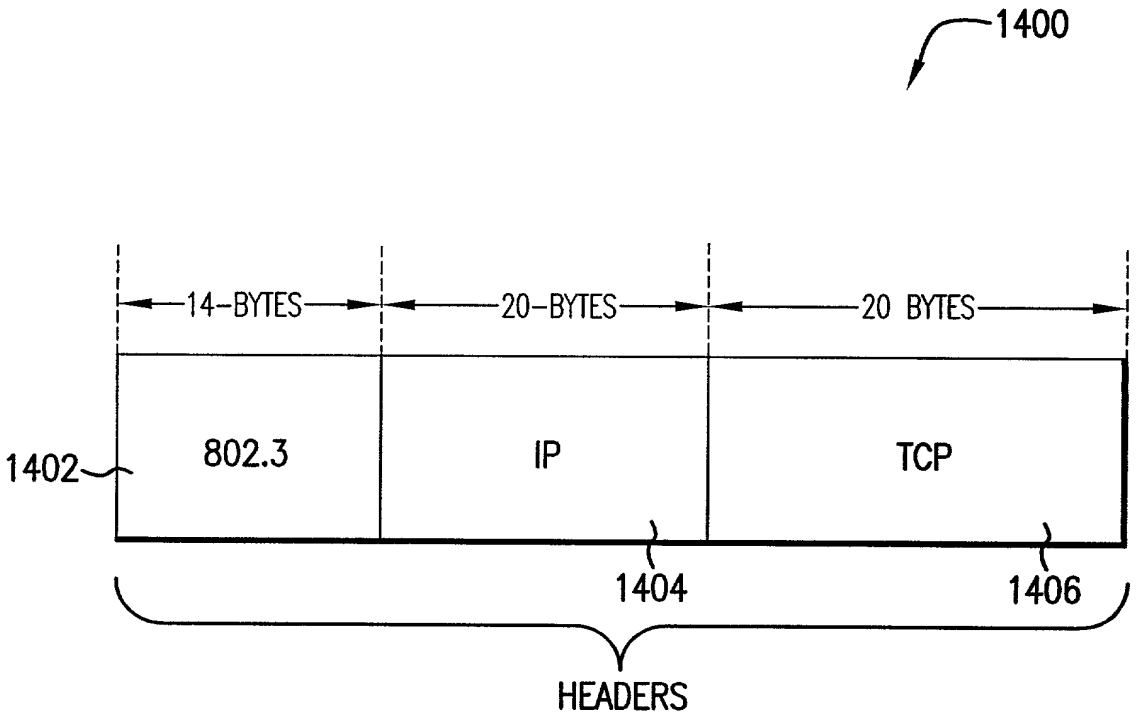
1400
14-BYTES
20-BYTES
20 BYTES
802.3
IP
TCP
1402
1404
1406
HEADERS

FIG.14A

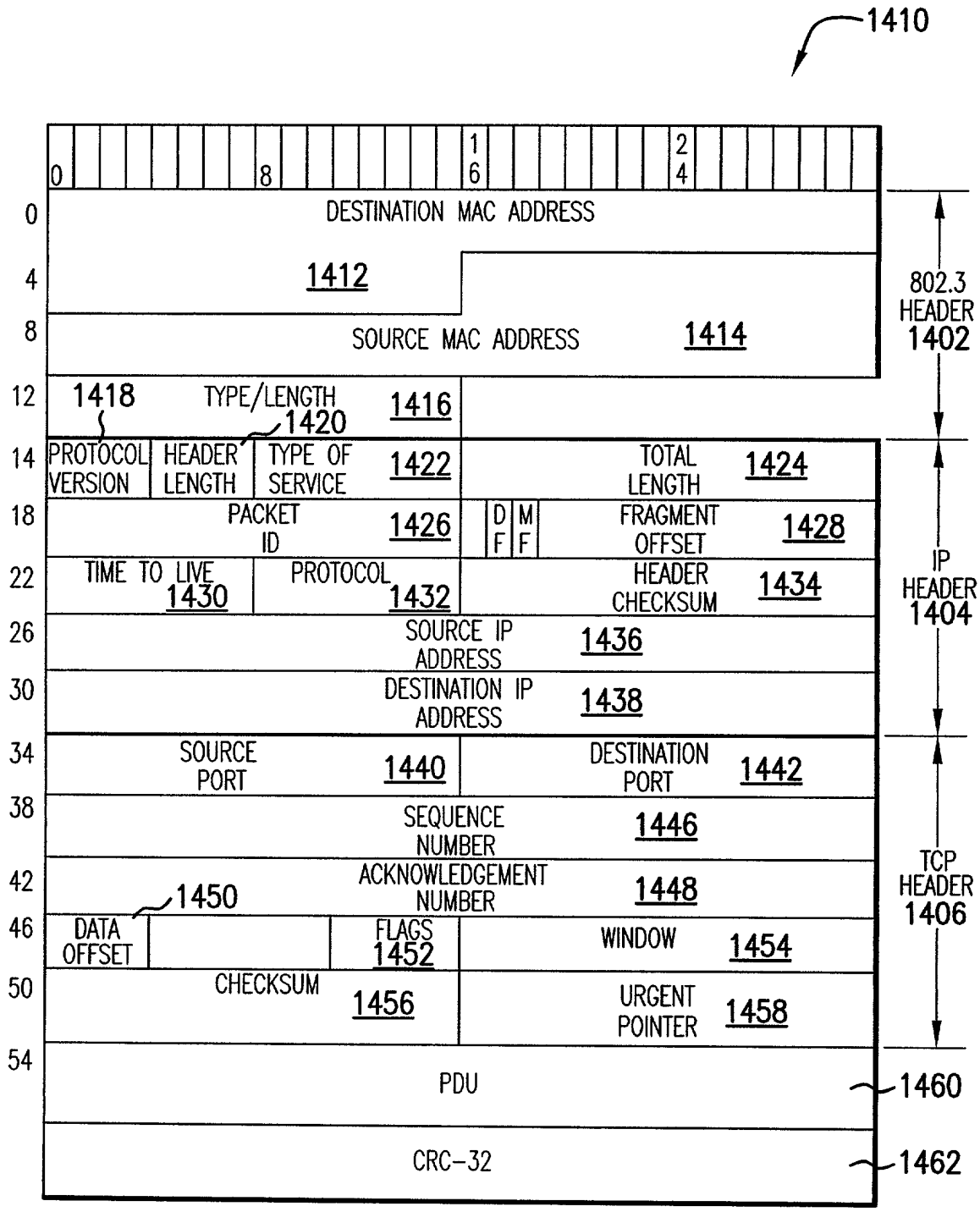
1410
0
8
16
24
0
DESTINATION MAC ADDRESS
4
1412
8
SOURCE MAC ADDRESS
1414
802.3 HEADER 1402
12
1418
TYPE/LENGTH
1420
1416
14
PROTOCOL VERSION
HEADER LENGTH
TYPE OF SERVICE
1422
TOTAL LENGTH
1424
18
PACKET ID
1426
DF
MF
FRAGMENT OFFSET
1428
22
TIME TO LIVE
1430
PROTOCOL
1432
HEADER CHECKSUM
1434
IP HEADER 1404
26
SOURCE IP ADDRESS
1436
30
DESTINATION IP ADDRESS
1438
34
SOURCE PORT
1440
DESTINATION PORT
1442
38
SEQUENCE NUMBER
1446
42
ACKNOWLEDGEMENT NUMBER
1448
1450
46
DATA OFFSET
FLAGS
1452
WINDOW
1454
50
CHECKSUM
1456
URGENT POINTER
1458
TCP HEADER 1406
54
PDU
1460
CRC-32
1462

FIG.14B

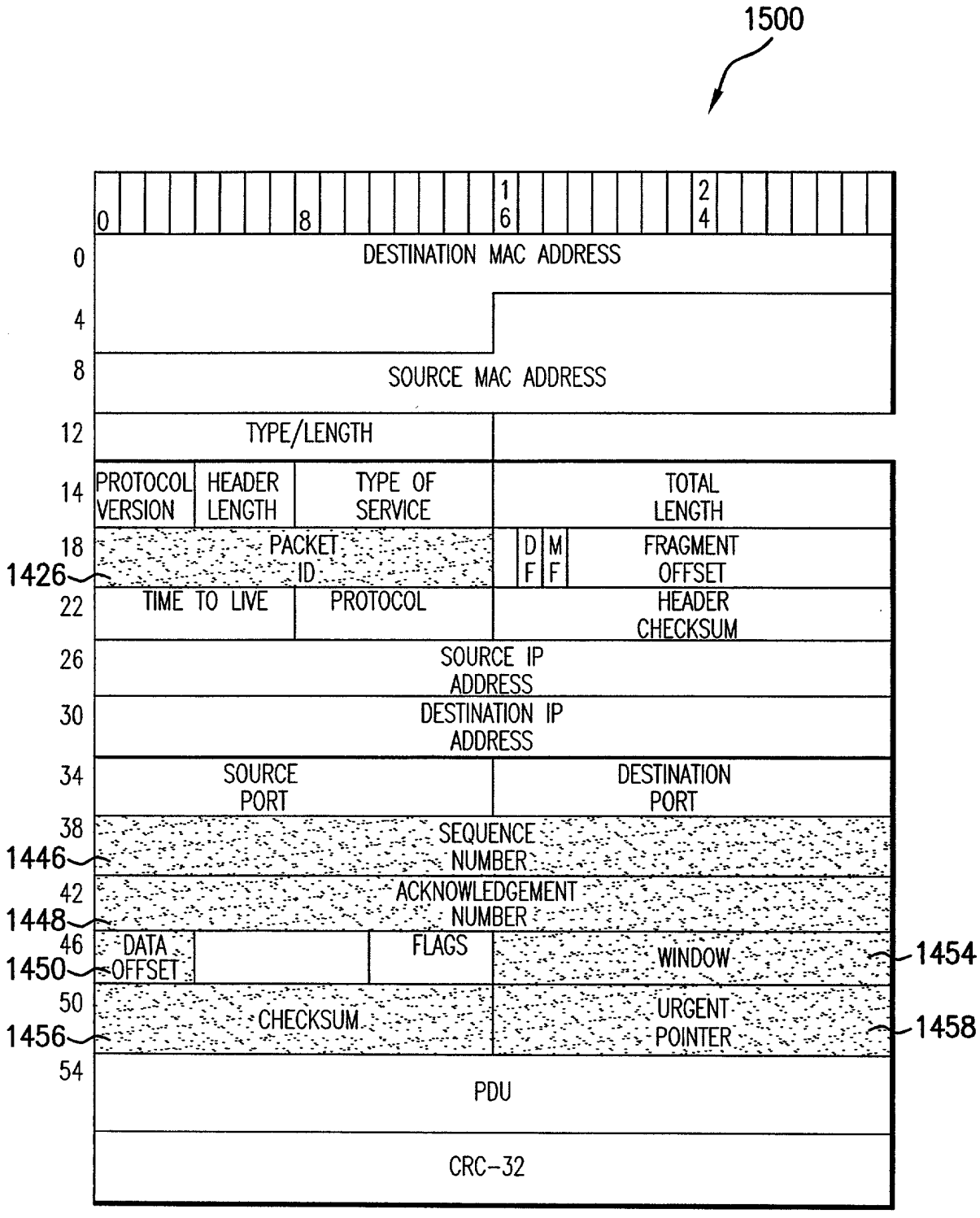
1500
0
8
16
24
0
DESTINATION MAC ADDRESS
4
8
SOURCE MAC ADDRESS
12
TYPE/LENGTH
14
PROTOCOL VERSION
HEADER LENGTH
TYPE OF SERVICE
TOTAL LENGTH
18
1426
PACKET ID
D F
M F
FRAGMENT OFFSET
22
TIME TO LIVE
PROTOCOL
HEADER CHECKSUM
26
SOURCE IP ADDRESS
30
DESTINATION IP ADDRESS
34
SOURCE PORT
DESTINATION PORT
38
1446
SEQUENCE NUMBER
42
1448
ACKNOWLEDGEMENT NUMBER
46
1450
DATA OFFSET
FLAGS
WINDOW
1454
50
1456
CHECKSUM
URGENT POINTER
1458
54
PDU
CRC-32

FIG.15

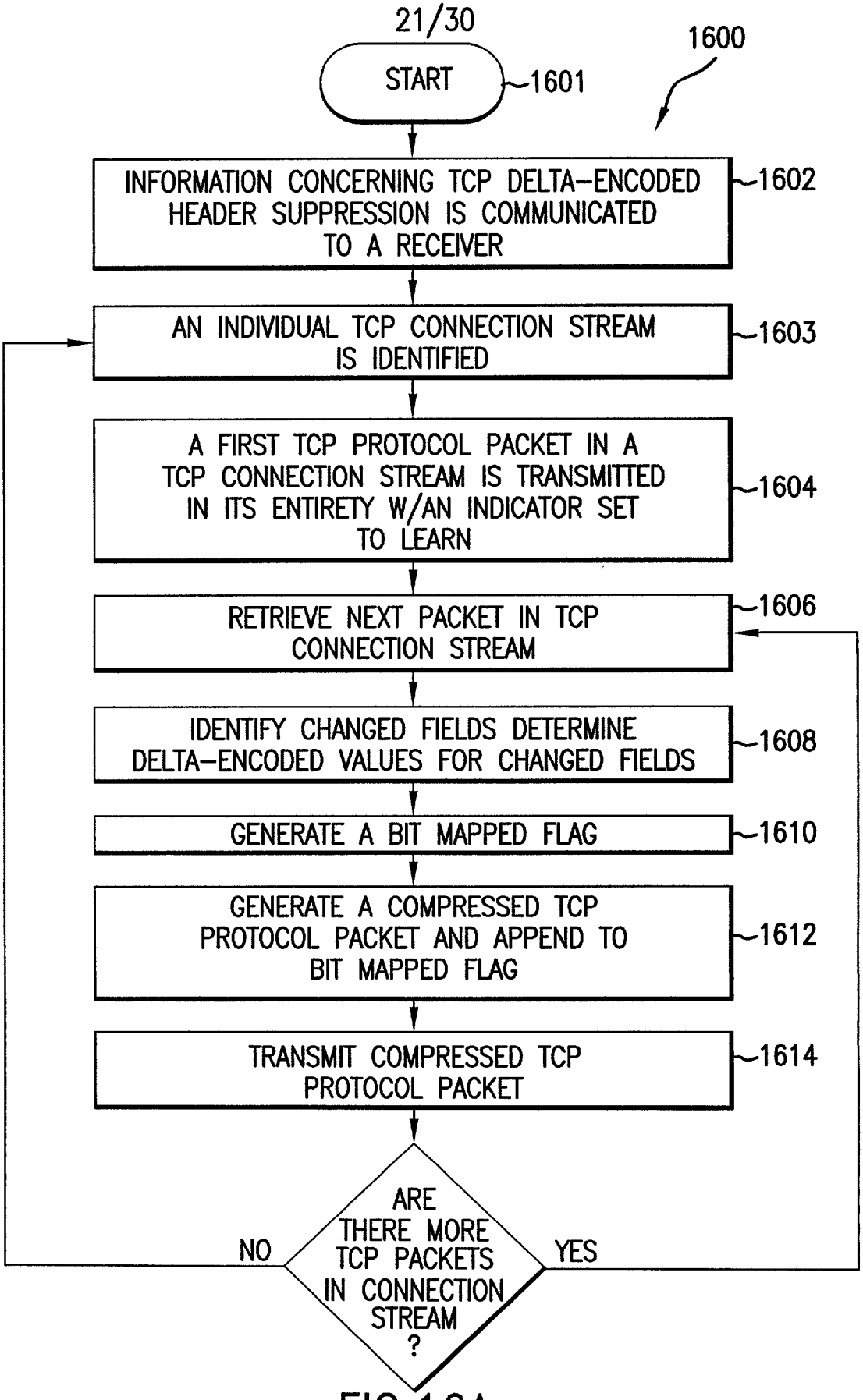
1600
START
1601
INFORMATION CONCERNING TCP DELTA-ENCODED HEADER SUPPRESSION IS COMMUNICATED TO A RECEIVER
1602
AN INDIVIDUAL TCP CONNECTION STREAM IS IDENTIFIED
1603
A FIRST TCP PROTOCOL PACKET IN A TCP CONNECTION STREAM IS TRANSMITTED IN ITS ENTIRETY W/AN INDICATOR SET TO LEARN
1604
RETRIEVE NEXT PACKET IN TCP CONNECTION STREAM
1606
IDENTIFY CHANGED FIELDS DETERMINE DELTA-ENCODED VALUES FOR CHANGED FIELDS
1608
GENERATE A BIT MAPPED FLAG
1610
GENERATE A COMPRESSED TCP PROTOCOL PACKET AND APPEND TO BIT MAPPED FLAG
1612
TRANSMIT COMPRESSED TCP PROTOCOL PACKET
1614
ARE THERE MORE TCP PACKETS IN CONNECTION STREAM ?
NO
YES

FIG.16A

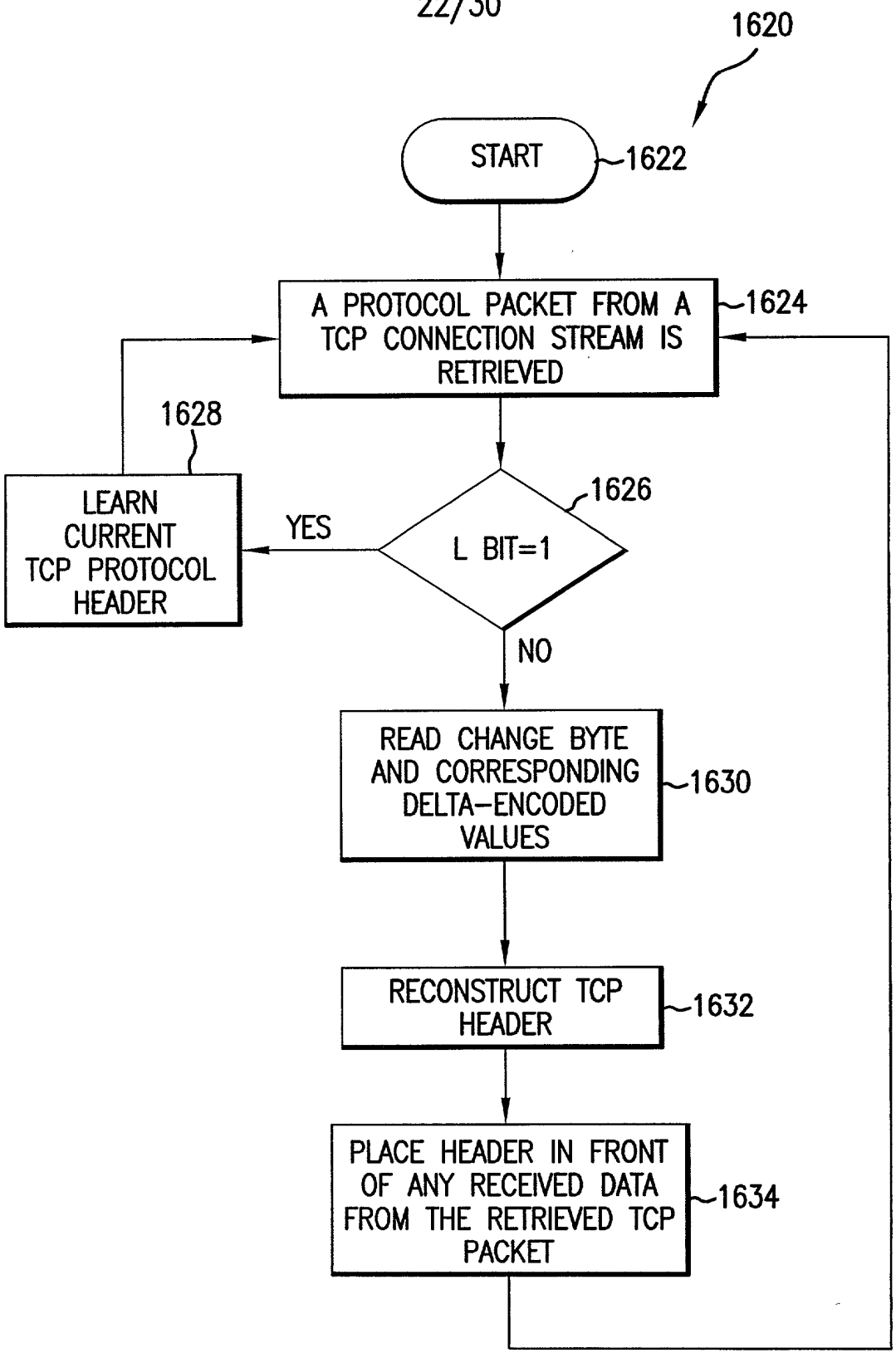
1620
START
1622
A PROTOCOL PACKET FROM A TCP CONNECTION STREAM IS RETRIEVED
1624
1628
LEARN CURRENT TCP PROTOCOL HEADER
YES
L BIT=1
1626
NO
READ CHANGE BYTE AND CORRESPONDING DELTA-ENCODED VALUES
1630
RECONSTRUCT TCP HEADER
1632
PLACE HEADER IN FRONT OF ANY RECEIVED DATA FROM THE RETRIEVED TCP PACKET
1634

FIG.16B

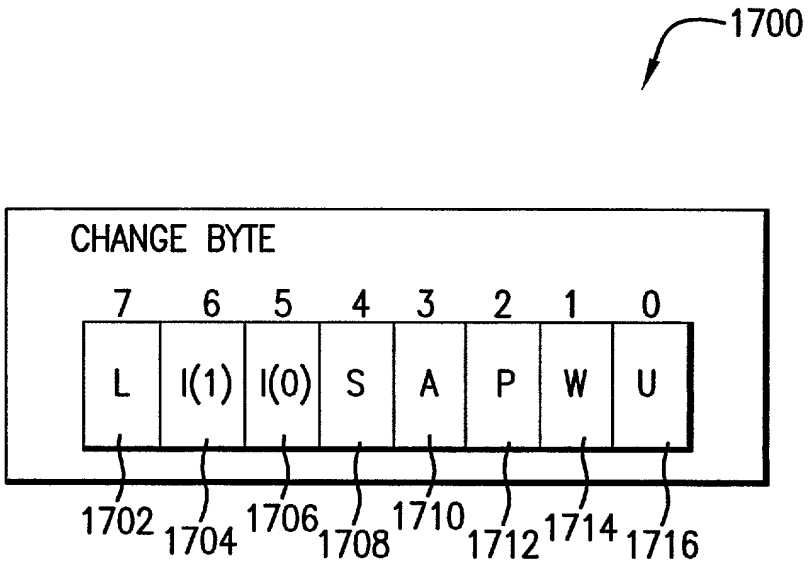
1700
CHANGE BYTE
7 6 5 4 3 2 1 0
L I(1) I(0) S A P W U
1702 1704 1706 1708 1710 1712 1714 1716

FIG.17

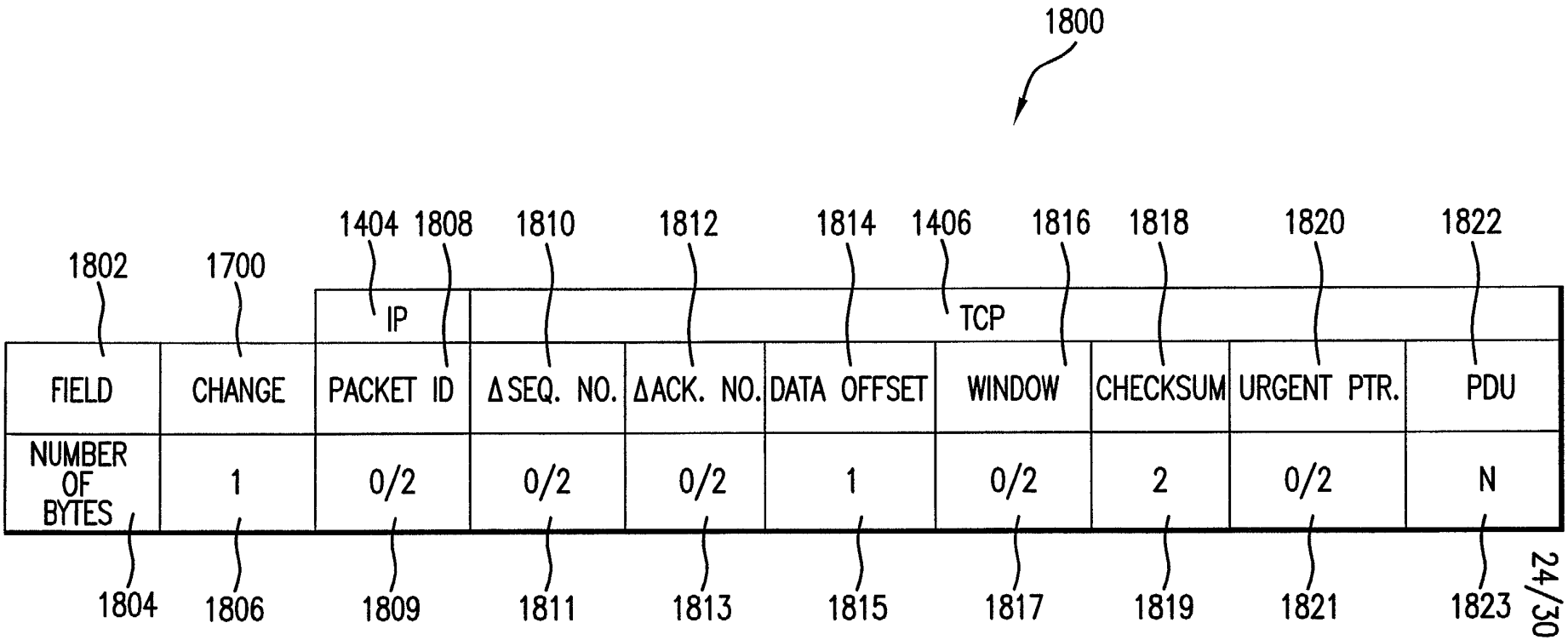
1800
1802
1700
1404
1808
1810
1812
1814
1406
1816
1818
1820
1822
IP
TCP
FIELD
CHANGE
PACKET ID
ΔSEQ. NO.
ΔACK. NO.
DATA OFFSET
WINDOW
CHECKSUM
URGENT PTR.
PDU
NUMBER OF BYTES
1
0/2
0/2
0/2
1
0/2
2
0/2
N
1804
1806
1809
1811
1813
1815
1817
1819
1821
1823

FIG.18

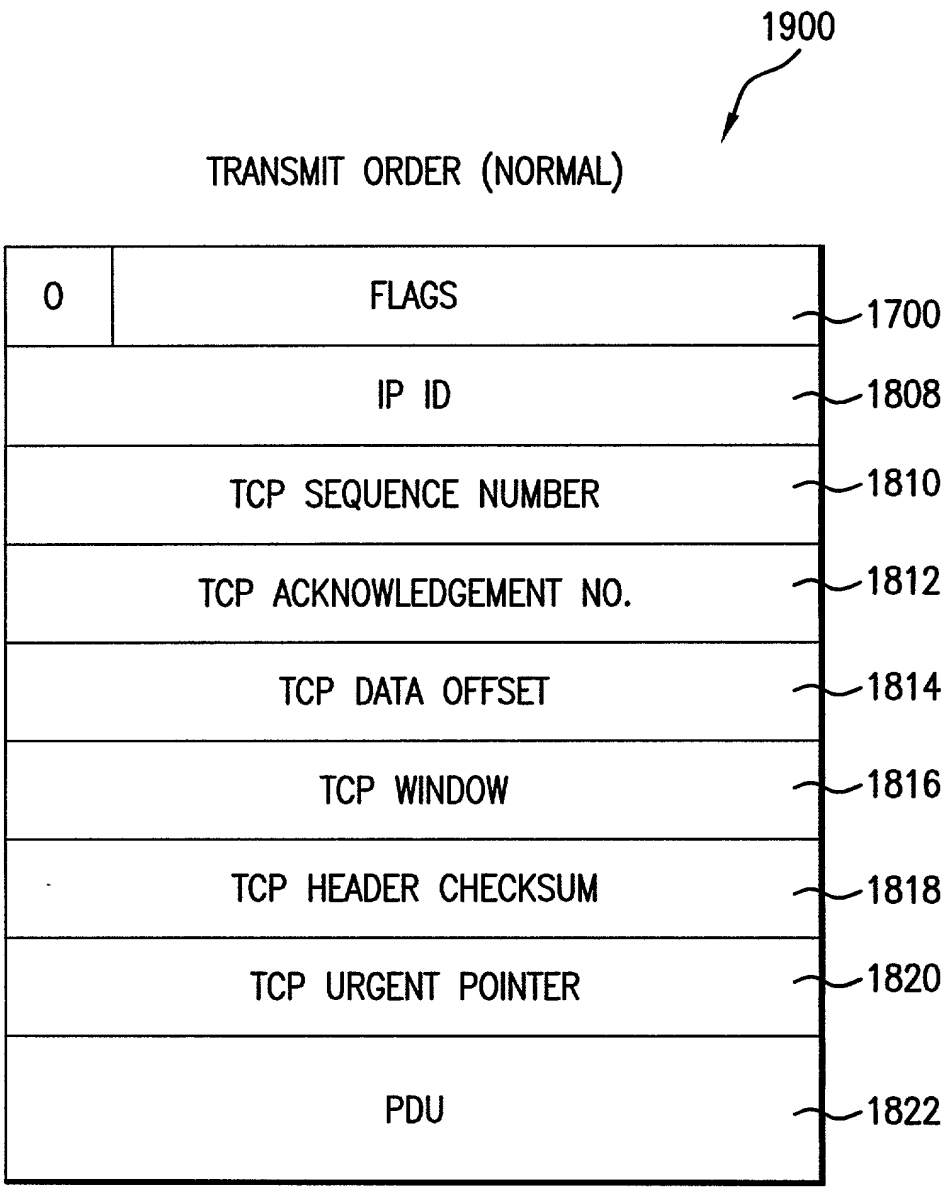
1900
TRANSMIT ORDER (NORMAL)
0
FLAGS
1700
IP ID
1808
TCP SEQUENCE NUMBER
1810
TCP ACKNOWLEDGEMENT NO.
1812
TCP DATA OFFSET
1814
TCP WINDOW
1816
TCP HEADER CHECKSUM
1818
TCP URGENT POINTER
1820
PDU
1822

FIG.19

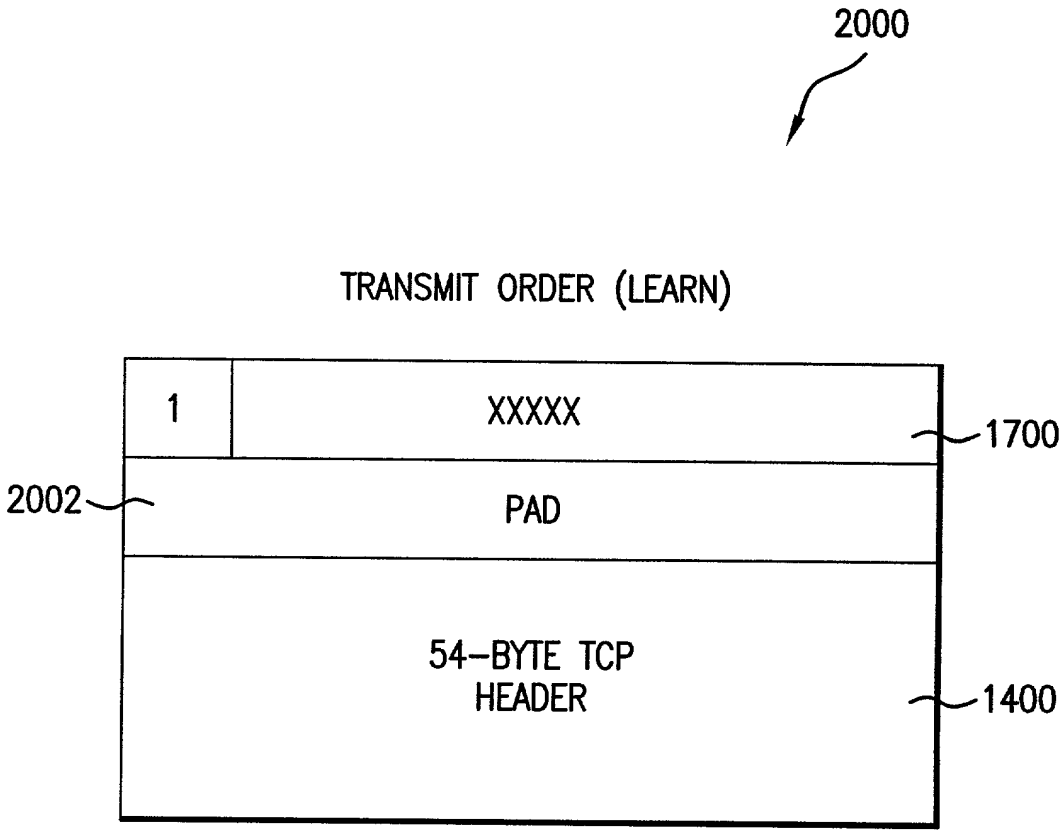
2000
TRANSMIT ORDER (LEARN)
1
XXXXX
1700
2002
PAD
54-BYTE TCP
HEADER
1400

FIG.20

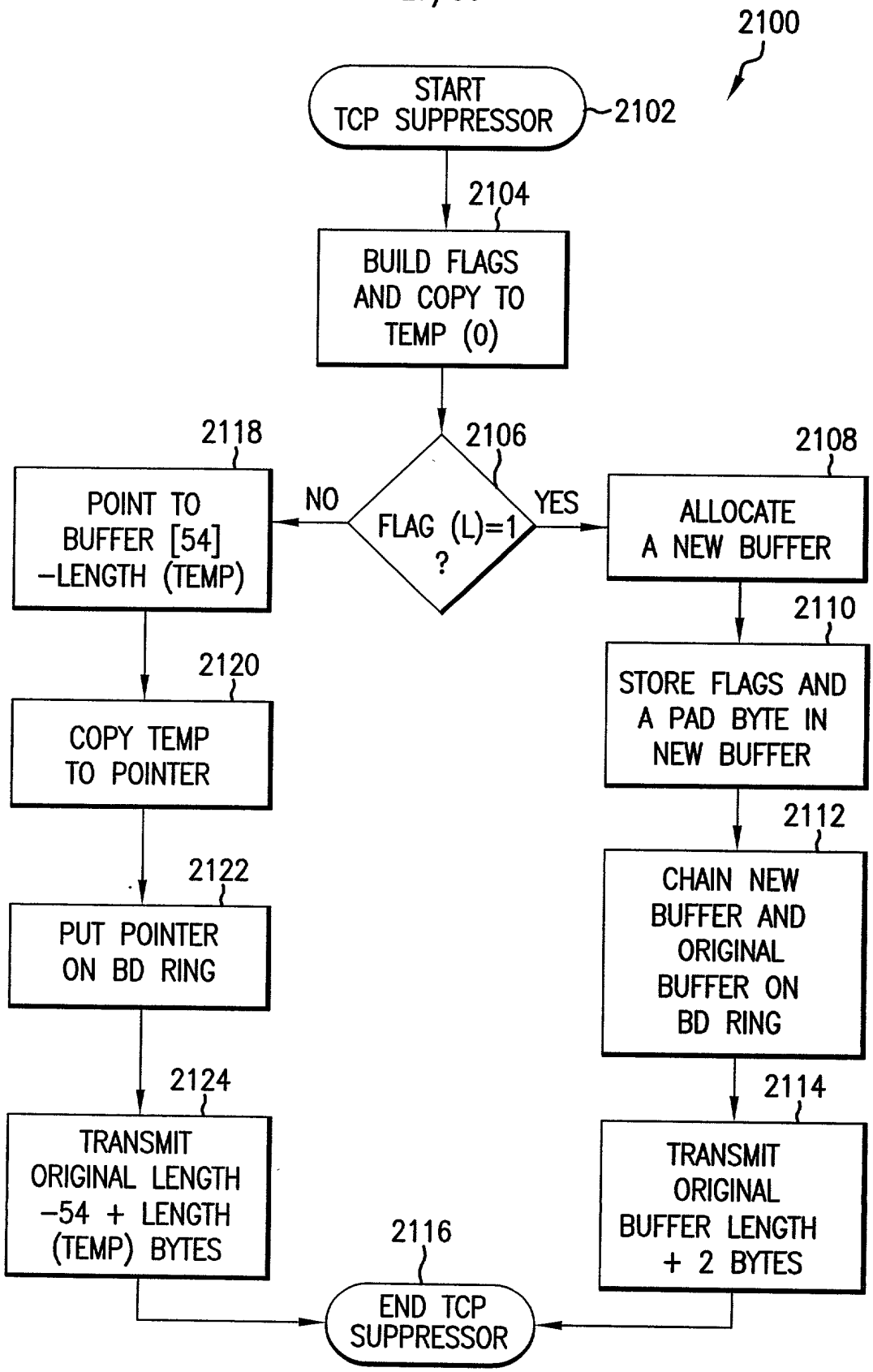
2100
START TCP SUPPRESSOR
2102
2104
BUILD FLAGS AND COPY TO TEMP (0)
2106
FLAG (L)=1 ?
NO
YES
2118
POINT TO BUFFER [54] −LENGTH (TEMP)
2108
ALLOCATE A NEW BUFFER
2110
STORE FLAGS AND A PAD BYTE IN NEW BUFFER
2112
CHAIN NEW BUFFER AND ORIGINAL BUFFER ON BD RING
2114
TRANSMIT ORIGINAL BUFFER LENGTH + 2 BYTES
2120
COPY TEMP TO POINTER
2122
PUT POINTER ON BD RING
2124
TRANSMIT ORIGINAL LENGTH −54 + LENGTH (TEMP) BYTES
2116
END TCP SUPPRESSOR

FIG.21

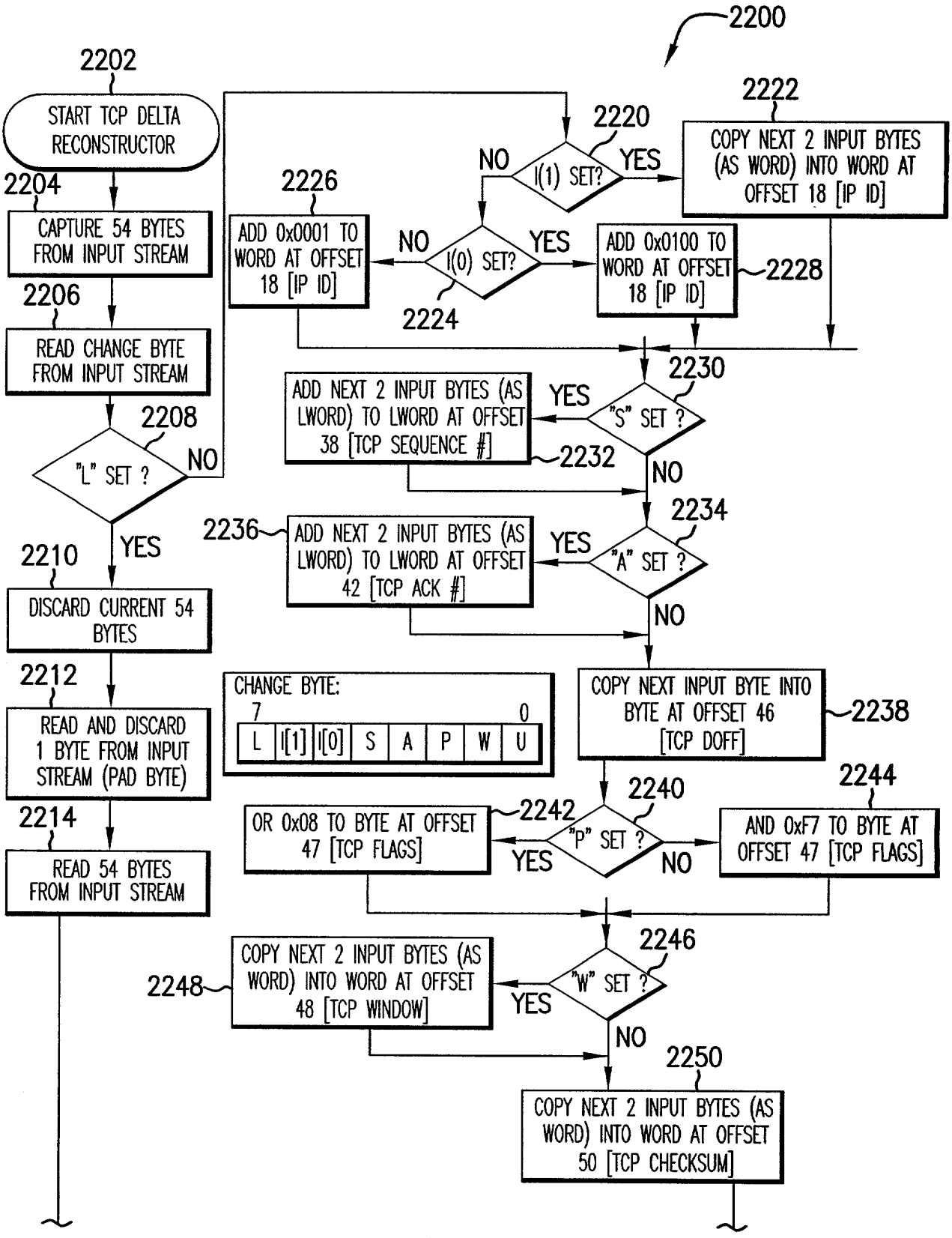
2200
2202
START TCP DELTA RECONSTRUCTOR
2204
CAPTURE 54 BYTES FROM INPUT STREAM
2206
READ CHANGE BYTE FROM INPUT STREAM
2208
"L" SET ?
NO
YES
2210
DISCARD CURRENT 54 BYTES
2212
READ AND DISCARD 1 BYTE FROM INPUT STREAM (PAD BYTE)
2214
READ 54 BYTES FROM INPUT STREAM
2220
I(1) SET?
NO
YES
2222
COPY NEXT 2 INPUT BYTES (AS WORD) INTO WORD AT OFFSET 18 [IP ID]
2224
I(0) SET?
NO
YES
2226
ADD 0x0001 TO WORD AT OFFSET 18 [IP ID]
2228
ADD 0x0100 TO WORD AT OFFSET 18 [IP ID]
2230
"S" SET ?
YES
NO
2232
ADD NEXT 2 INPUT BYTES (AS LWORD) TO LWORD AT OFFSET 38 [TCP SEQUENCE #]
2234
"A" SET ?
YES
NO
2236
ADD NEXT 2 INPUT BYTES (AS LWORD) TO LWORD AT OFFSET 42 [TCP ACK #]
CHANGE BYTE:
7
0
L
I[1]
I[0]
S
A
P
W
U
2238
COPY NEXT INPUT BYTE INTO BYTE AT OFFSET 46 [TCP DOFF]
2240
"P" SET ?
YES
NO
2242
OR 0x08 TO BYTE AT OFFSET 47 [TCP FLAGS]
2244
AND 0xF7 TO BYTE AT OFFSET 47 [TCP FLAGS]
2246
"W" SET ?
YES
NO
2248
COPY NEXT 2 INPUT BYTES (AS WORD) INTO WORD AT OFFSET 48 [TCP WINDOW]
2250
COPY NEXT 2 INPUT BYTES (AS WORD) INTO WORD AT OFFSET 50 [TCP CHECKSUM]

FIG.22A

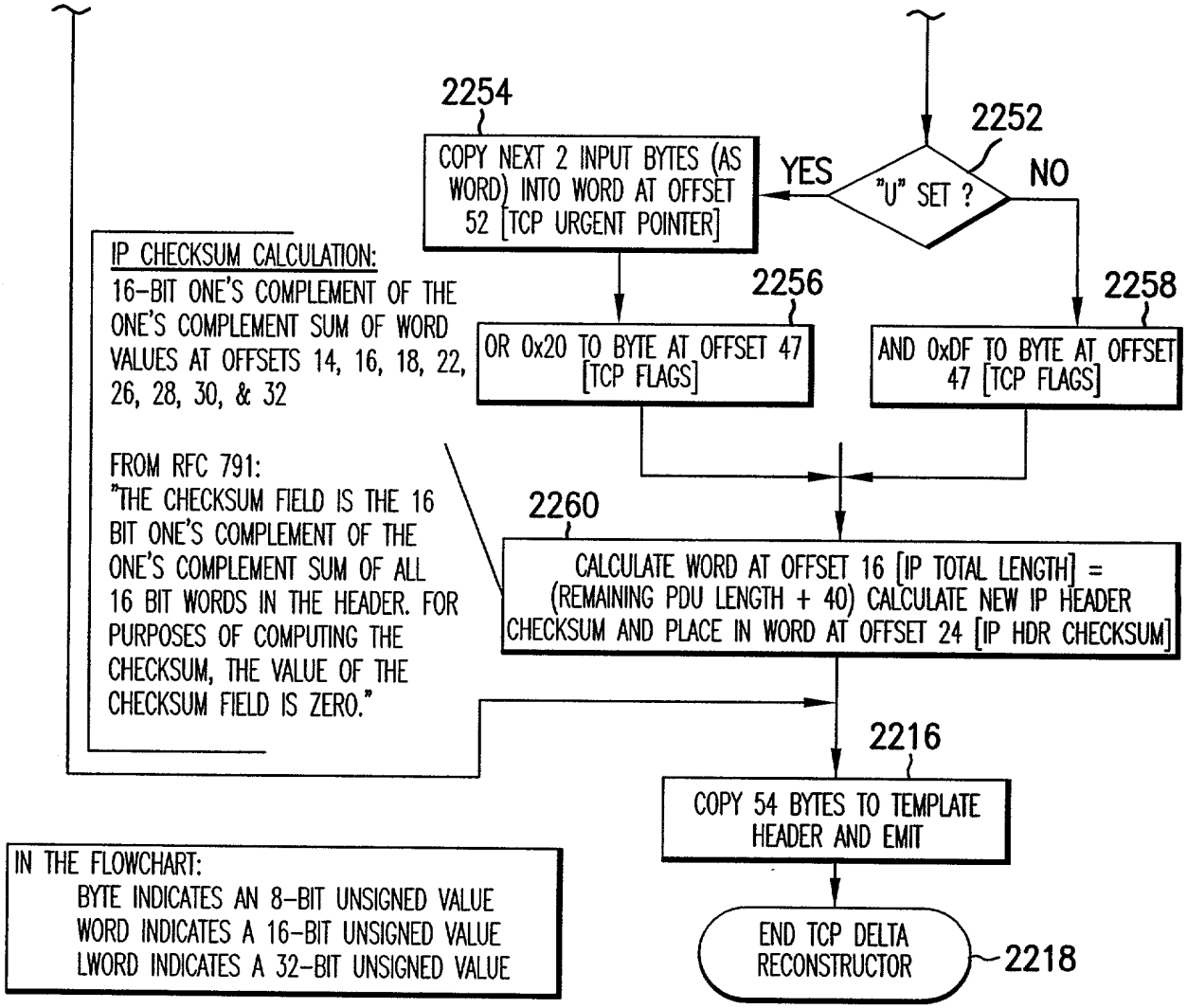
2254
COPY NEXT 2 INPUT BYTES (AS WORD) INTO WORD AT OFFSET 52 [TCP URGENT POINTER]
YES
2252
"U" SET ?
NO
IP CHECKSUM CALCULATION:
16-BIT ONE'S COMPLEMENT OF THE ONE'S COMPLEMENT SUM OF WORD VALUES AT OFFSETS 14, 16, 18, 22, 26, 28, 30, & 32
FROM RFC 791:
"THE CHECKSUM FIELD IS THE 16 BIT ONE'S COMPLEMENT OF THE ONE'S COMPLEMENT SUM OF ALL 16 BIT WORDS IN THE HEADER. FOR PURPOSES OF COMPUTING THE CHECKSUM, THE VALUE OF THE CHECKSUM FIELD IS ZERO."
2256
OR 0x20 TO BYTE AT OFFSET 47 [TCP FLAGS]
2258
AND 0xDF TO BYTE AT OFFSET 47 [TCP FLAGS]
2260
CALCULATE WORD AT OFFSET 16 [IP TOTAL LENGTH] = (REMAINING PDU LENGTH + 40) CALCULATE NEW IP HEADER CHECKSUM AND PLACE IN WORD AT OFFSET 24 [IP HDR CHECKSUM]
2216
COPY 54 BYTES TO TEMPLATE HEADER AND EMIT
END TCP DELTA RECONSTRUCTOR
2218
IN THE FLOWCHART:
BYTE INDICATES AN 8-BIT UNSIGNED VALUE
WORD INDICATES A 16-BIT UNSIGNED VALUE
LWORD INDICATES A 32-BIT UNSIGNED VALUE

FIG.22B

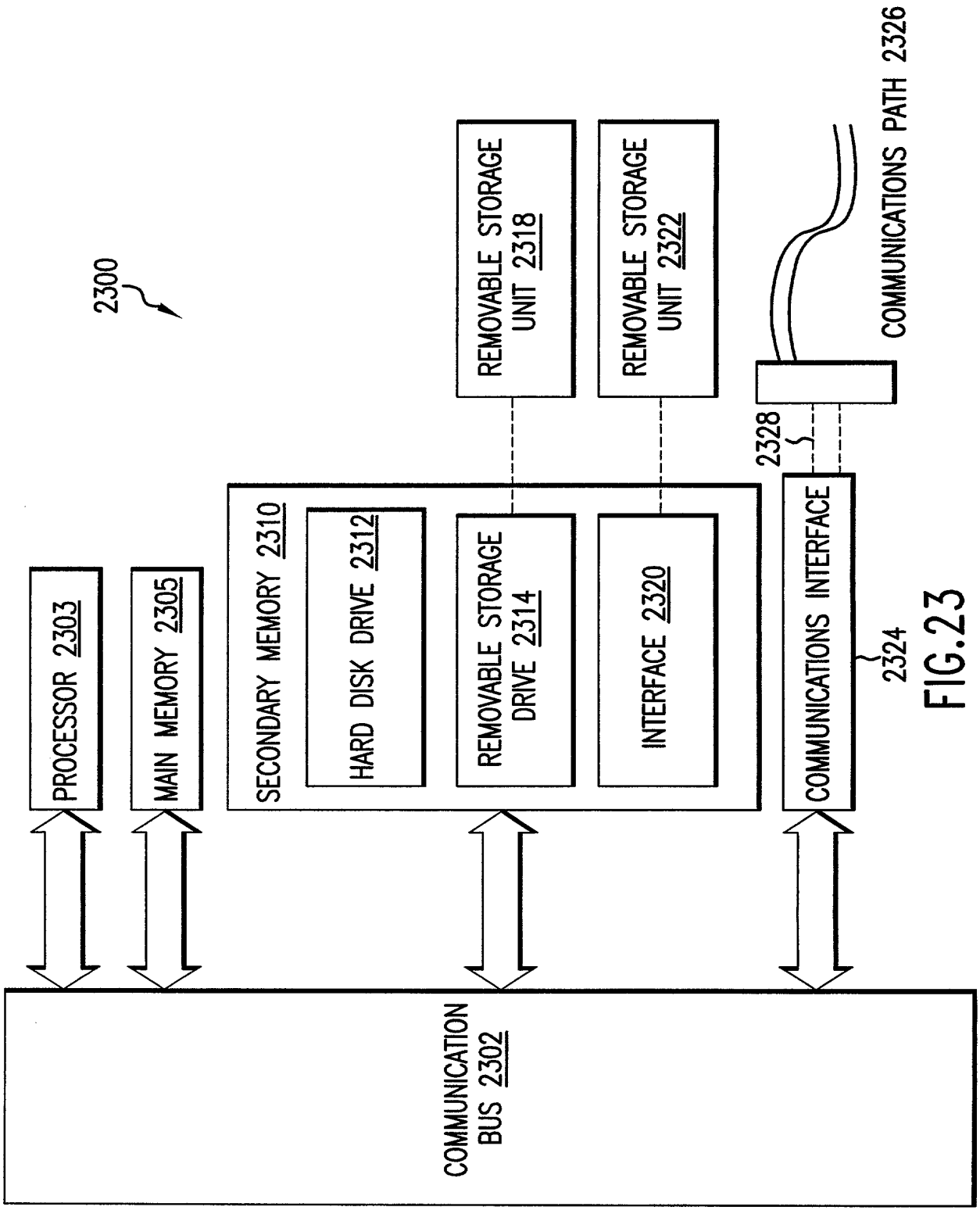
2300
PROCESSOR 2303
MAIN MEMORY 2305
SECONDARY MEMORY 2310
HARD DISK DRIVE 2312
REMOVABLE STORAGE DRIVE 2314
INTERFACE 2320
REMOVABLE STORAGE UNIT 2318
REMOVABLE STORAGE UNIT 2322
COMMUNICATIONS INTERFACE
2324
2328
COMMUNICATIONS PATH 2326
COMMUNICATION BUS 2302

FIG.23